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Mineralogical Society

OF

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THE MINERALOGICAL SOCIETY

Mineralogical Society of Great Britain & Ireland.

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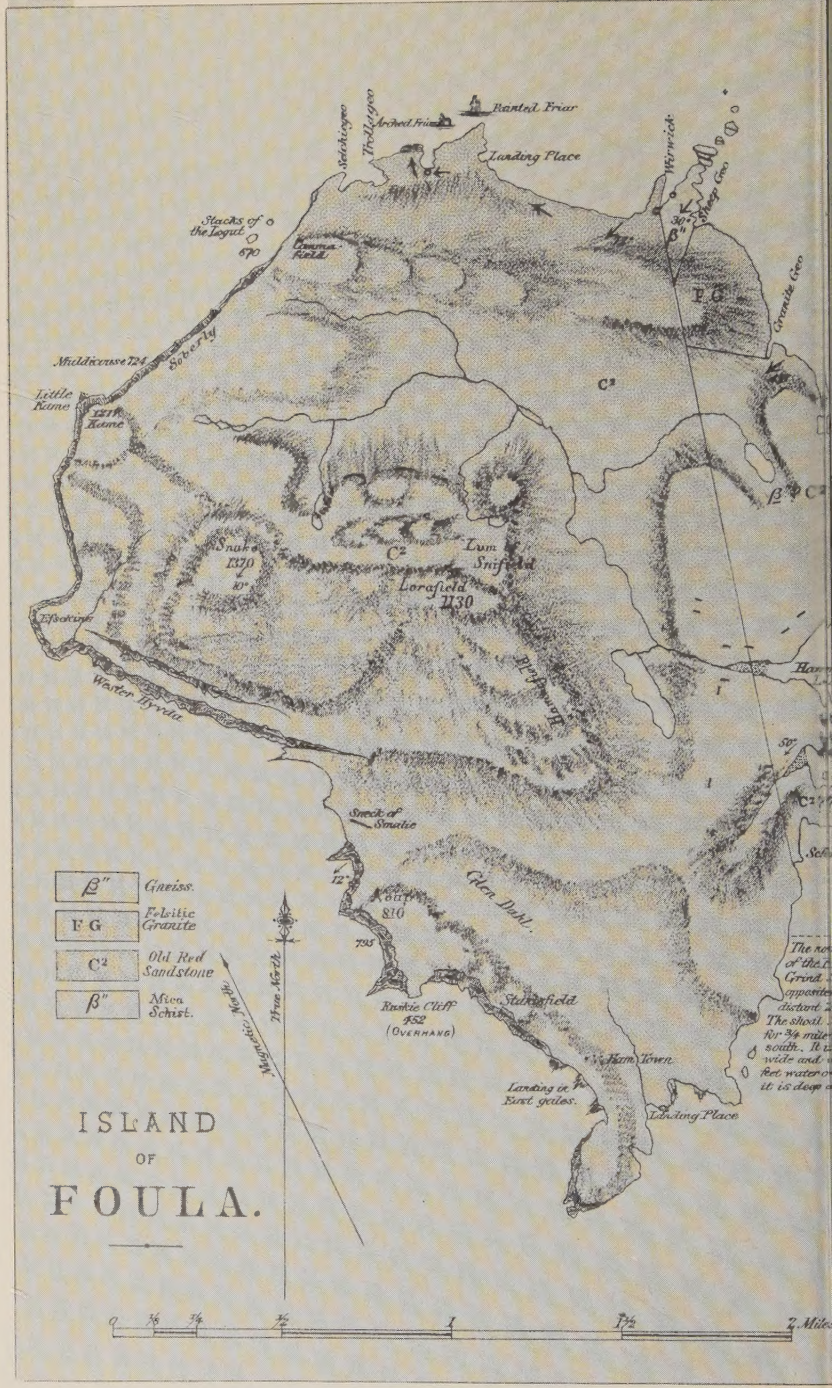

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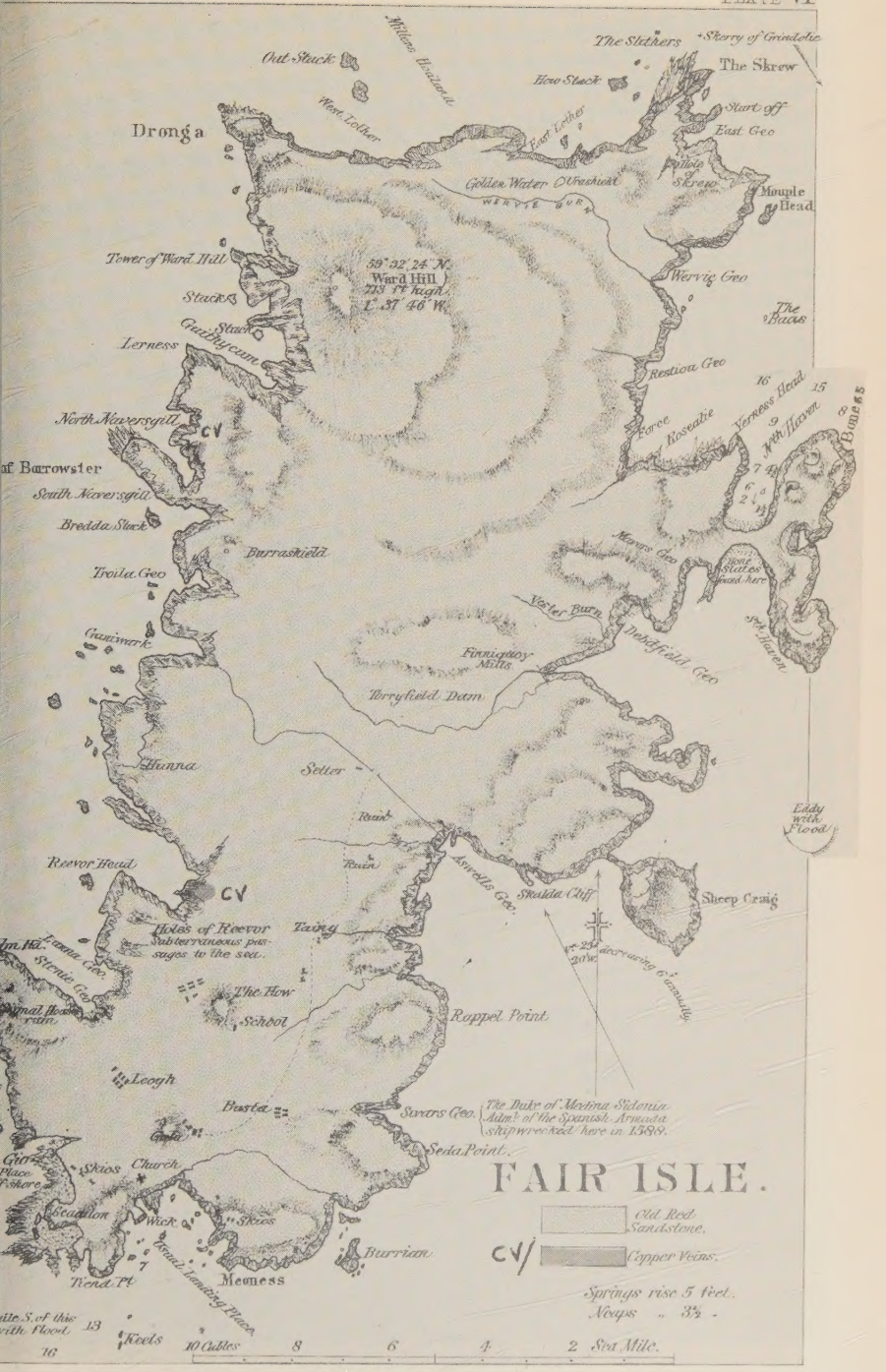

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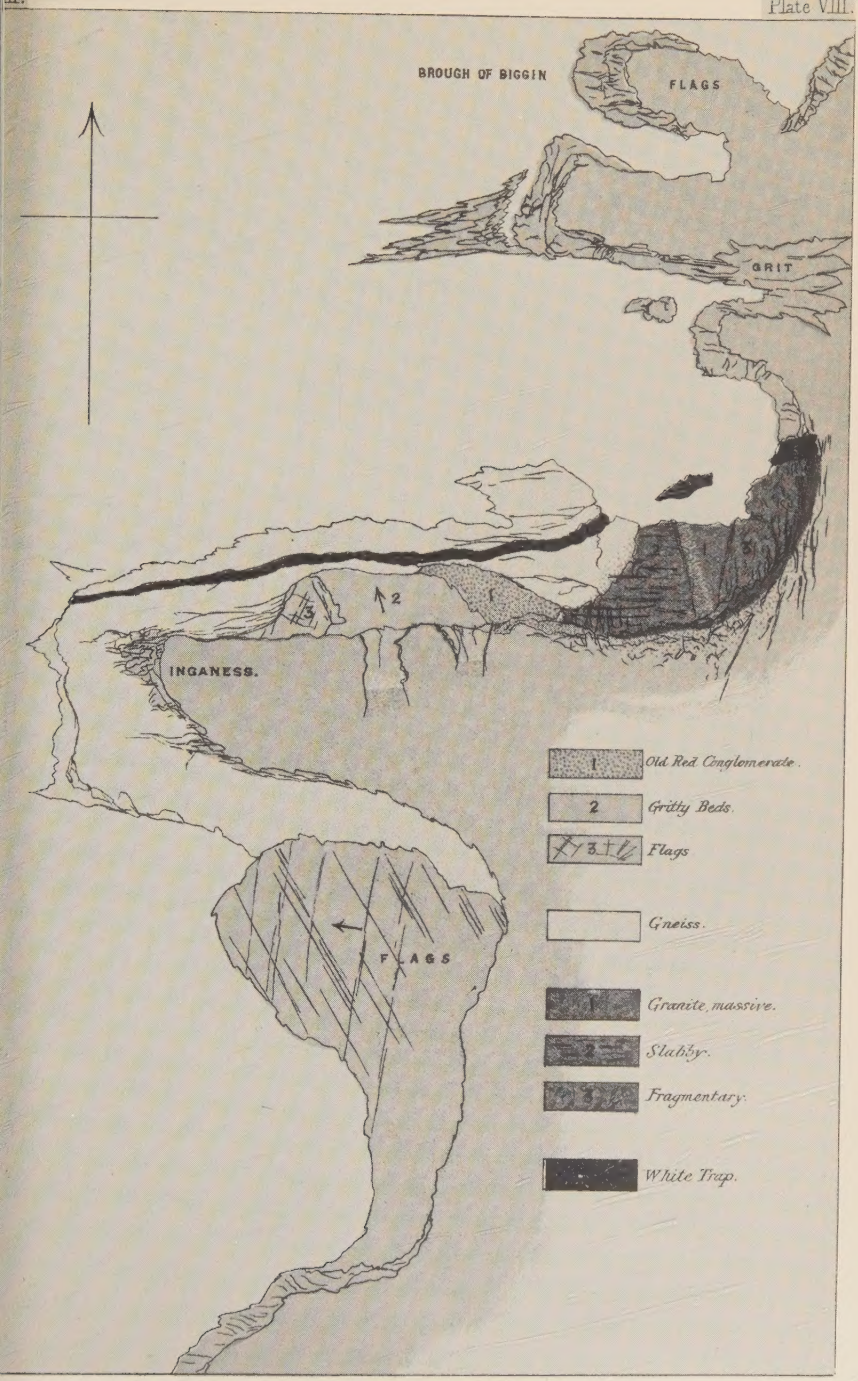

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FIG. 4.

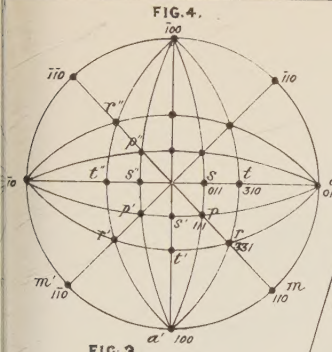


FIG. 5.

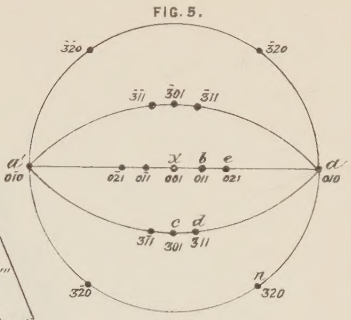


FIG. 3.

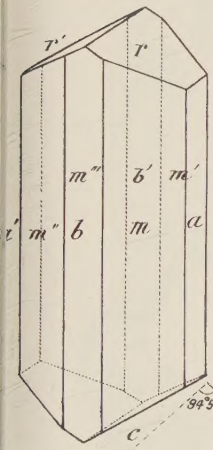


FIG. 2.

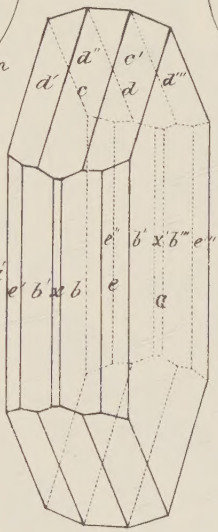


FIG. 2a

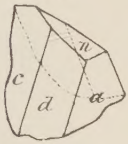


FIG. 7.

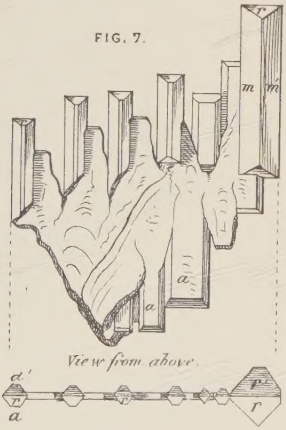


FIG. 6.

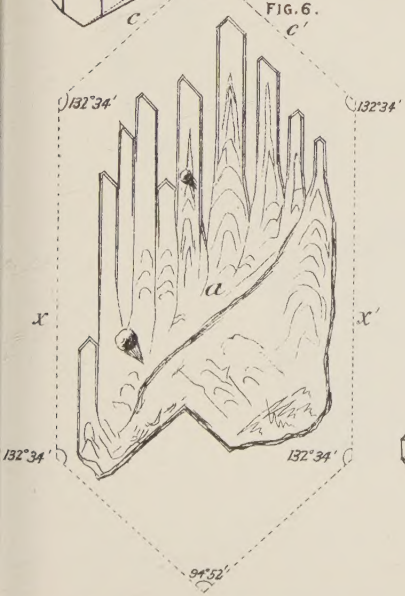
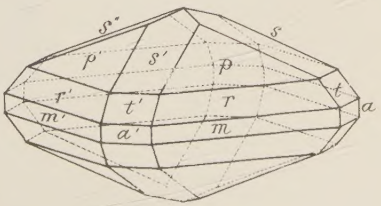


FIG. 1.



LAKE & LAKE, LITH. TRURO.

"HORSE-TOOTH STONE".

FROM ABOVE.

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"HORSE-TOOTH STONE."
TRANSVERSE FRACTURE.

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EXCERPT MINUTES OF COUNCIL MEETING,

Held at 116, *Victoria Street, October* 21*st*, 1879.

Prof. M. F. Heddle, F.R.S.E., President, in the Chair.

The Secretary reported the death of Prof. B. von Cotta, one of the corresponding members of the Society, when it was

Resolved:—That the Foreign Secretary be requested to write a letter of condolence to the family of the late Professor.

The following resolutions were also passed *nem: con.*

Resolved:—That Prof. Sella be elected a corresponding member of this Society in place of the late Prof. B. von. Cotta.

Resolved:—That Mr. Collins be requested to continue to edit the Magazine for the forthcoming year, and to accept of the honorarium of Twenty Pounds.

Mr. Henry Louis, Assoc. R.S.M. of Derwent House, Derwent Road, Anerley, was elected as an ordinary member. Mr. James Smith, of Bridge Street, Manchester, was elected as an Associate.

GENERAL MEETING.

Held at 116, *Victoria Street, London, W., October* 21*st*, 1879.

Prof. M. F. Heddle, F.R.S.E., President, in the Chair.

The Minutes of the Sheffield Meeting were read and confirmed, and the President expressed his thanks to the members for his election.

The following papers were read and discussed—

On the Mineralogy and Geognosy of the Orkney Islands, Part I., by the President.

On a probably Dimorphous form of tin, and on some crystals found associated with it, by Dr. C. O. Trechmann and Mr. J. H. Collins.

On a peculiar pasty form of Silica from a cavity in gold-bearing quartz by Mr. A. French.

On some Cornish Tin-stones and Tin-capels, by Mr. J. H. Collins.

Experiments on the Elasticity of Crystals, by Prof. John Milne.

Mr. Watson, of Pall Mall, exhibited and explained his new Microscope for Petrological research.

A vote of thanks was passed to Mr. R. H. Scott for his kindness in permitting the use of his rooms for the Meeting.

BOOKS RECEIVED.

From *Prof. Jas. D. Dana*, Newhaven. American Journal of Science.—November and December, 1879.

„ *Prof. D'Achiardi*, Pisa. Atti della Soc. Tosc. di Sci Nat. Proc., Verb. Vol. 1 pp. 1-16.

„ *Prof. Groth*, Strasburg. Zeit. für Kryst. und Min. Band IV, Heft. 2.

„ *Soc. Geol. de Belg.* Liege. Annales, tome V, 1877-8.

„ *Reale Comitato Geologico*, Rome. Bolletino, 9 and 10, 1879.

„ *Soc. Cientif. Argentino*, Buenos Ayres. Annales, September to November, 1879

„ *A. W. Howitt*, Gippsland. The Diorites and Granites of Swifts Creek, and their contact zones, with notes on the auriferous deposits.

„ *F. R. Mallet, F.G.S.* On Corundum from the Khàsi Hills.

„ „ On Mysorin and Atacamite from the Nillore District.

„ *A. Damour*, Paris. Sur une obsidienne de l'Inde qui a éclaté avec detonation au moment où on la sciait.

„ „ Note sur un moyen de rèsoudre synthetiquement plusieres des principales questions de cristallographie, by G. Delafosse.

„ „ Géogénie des minerais calaminaires de zinc, plomb, et fer en gites irrèguliers, by M J. Delanoüe.

„ „ Sur la densité de quelques substances (quartz, coryndon, metaux, &c.,) apres fusion et refroidissement rapide, by M. Charles St. Clair Deville.

„ „ Note sur la double réfraction artificiellement produite dans des cristaux du systeme regulier, by M. Wertheim

„ „ Sur l'Apatite, la Wagnerite et quelques especès artificielles de phosphates métalliques, by M. M. St. Clair Deville and H Caron.

„ „ Sur les soufflures de l' Acier, by H. Caron.

„ „ Report on a Memoir by M. Hugand, entitled "Etude cristallographique de la strontiane sulfateé.

P. H Argall. Notes on Ancient and Recent Mining Operations in the East Ovoca District.

M. Delesse, Paris. Explosion d' acide carbonique dans une mine de houille.

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MINERALOGICAL SOCIETY OF GREAT BRITAIN AND IRELAND

No. 15. DECEMBER, 1879. Vol. III.

XVII.—*The Geognosy and Mineralogy of Scotland.*

By Professor Heddle.

THE ORKNEY ISLANDS.

Part I.

JAMESON tells us that it took him six weeks to survey Orkney geologically, and that the journey was the most uninteresting he ever made; his journal, indeed, is little more than a record of disappointments. Jameson's statement, so far from concealing, disclosed an indubitable fact, that to relieve the tedium of the hammer through weeks of wandering, some impulse,—some attraction of a different nature must be associated with it. Jameson himself showed that such attraction was present with him, though he seems to have put a restraint upon himself as regards the alluding to it.

In his preface he says—"I hope that I have not been insensible to the emotions which naturally arise from the retired and striking scenes which often burst upon me in the unfrequented tracks which my pursuits led me to explore:"—and though he expressly states that it is not his "purpose to obtrude these things," still "these things"—the stimulus of the grandeur of nature—the secrets of nature acting as the loadstone to his desire to unfold their workings,—these things do occasionally break through even his reserve, but not obtrusively.

That the impulse necessary for alleviating the burden of the hammer should have been comparatively dormant if Jameson had visited Orkney after having left Shetland might not be surprising. In comparison

with that land of many diverse strata, the unvarying monotony of the glaciated contours, and half-submerged sandbanks of an Old Red Sandstone country must have proved tame indeed; but there can be little doubt that if Jameson had made his survey of *Caithness* anteriorly to that of Orkney, his expressions of discontent and disappointment would have been so thoroughly expended on that more monotonous and most mineralogically-barren land, that a feeling of relief if not of interest would have been experienced while Orkney was being surveyed.

It is sufficiently significant in this connection to notice that, while the survey of Orkney occupies seventeen pages of his work, Caithness is dismissed in six.*

But while admitting that Orkney is to the mere mineralogist a comparatively uninteresting country, it must be allowed that now that mineralogy is marching hand in hand with chemistry as the handmaid of geology, Orkney comes to be far from devoid of interest.

Geikie writes:—"In quitting Orkney I would refer to the many admirable sections exposed along the mural sea-cliffs of that storm-swept group of islands, and to the endless instructive lessons furnished by them on stratification, jointing, and other elementary questions in physical geology, as well as on the progress of weathering, its relations to rock structure, and the proportional share taken in it by the sea and the atmosphere."

The Orkneys are composed almost solely of rocks, till lately assigned wholly to Old Red Sandstone age.

This formation, though of the highest interest as regards its fossil ichthyology, is usually singularly barren in those rock features which aid in elucidating the changes through which the crust of the earth has been formed, and by which it has been affected; while it is also markedly barren as a field for the researches of the mineralogist.

The monotony which attaches to a single formation is, however, relieved somewhat by the occurrence of a narrow strip of older rocks in the west of the county;—by the unmistakable evidence afforded in one island that these Old Red Sandstones are not here to be assigned to *one* geologic epoch;—and by a great development of the system of trap-dykes, which occurs so markedly along our western coasts,—that namely of tertiary age and which has a W. and E., or W.N.W. and E.S.E strike.

* Jameson quits the Orkney Islands with a warm acknowledgement of a hospitality which was "confined to them"—a hospitality which "seemed to look for no return;" while of Caithness he has no hospitality to record; he designates it a "mean looking country, the tedious unformity of the bleak scene being only varied by the appearance of old ruinous castles, or recluse gentlemen's seats situated amid brown desert heaths." We find him say in one place—"we could get little to satisfy our craving hunger."

These rocks are considered by Geikie to have been laid down in the same basin as those of Shetland; and, so far as the sandstones of the west side of Shetland are concerned, this is doubtless true.

The sandstone rocks of Orkney however differ widely in lithological aspect from those of Shetland.

The grits and conglomerates, which were there seen in immediate contact with the older rocks, here find no place. If the deposited sands have been laid down in the same oceanic lake, the beds here seen occupy a much higher zone. Except at one spot where local circumstances alone have produced it, no bed of heterogenous or coarse-grained material, or containing recognisable fragments of an older rock, is to be seen. The beds which would appear to be the deepest-seated, are those which consist of the most highly-comminuted materials; argillaceous and slimy-looking silts and blue flags—sometimes glimmering from minutely interspersed mica, or "bituminous" from having been the recipients of the products of the death and decay which were taking place in supernatant waters which teemed with animal life*

The general dip to these beds is to the west; they are frequently however not far removed from the horizontal; undulating folds also run across the islands from east to west; and on both of these extremes the dip is, in the north of the county, at least towards the centre.

Up that centre, moreover, there runs a well marked trough which bears about N.E. to S.W., and the upper beds of this trough are markedly different from the rocks of the other parts of the islands.

This trough is in many parts submerged, but the beds which define it are well seen in their eastern limits, though to a much inferior extent in the western.

These beds consist of loose arenaceous freestones, with silicous granules sometimes so coarse as almost to entitle them to the designation of grits.

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*Jameson divides the beds into sandstone, sandstone-flag, schistose-clay, and indurated clay. Jameson's sandstone-flag he defines as schistose sandstone with a argillaceous cement.

His "schistose-clay" he thus defines.

"This rock has a black colour; is always intermixed with mica; and passes on the one hand into sandstone slate. and, on the other, into clay, where the schistose character is more difficultly distinguishable. It acquires by the action of the weather, an iron-brown covering; so that the rocks at a distance have much the appearance of the weathered serpentine rock in the Shetland Islands. It is quarried to a considerable extent in different parts of the island, particularly near to Stromness, and the slabs are used for roofing houses, but they are vastly inferior in every respect to the ardesia which is raised at Ballyhullish and Easdale."

This is the description of perhaps an unusually bitumenous variety of what is now called Caithness-flag, and it unquestionably passes into "sandstone-flag." Jameson makes it also pass into 'indurated clay.'

The lower series of beds are of a deep-red colour, from their containing much of a reddle-like mud disposed between the quartz grains, but this mud is of so clay-like a substance that it cannot be said to act the part of a cement to these grains. The upper beds are of a distinct yellow colour; the interstitial material is here not so large in quantity, but it partakes more of the nature of a cement.

The lower red bed is first seen in the north, on the west side of the bay of Pool in Sanday. It here forms low cliffs to the east, and strikes southward through the island in the direction of Spurness. It reappears to pass through Shapenshay from north to south, is again seen in low cliffs on the west shore of Birstane Bay in the mainland, re-appears (here associated with the yellow bed) at Scalpa, and finally forms the north-west corner of South Ronaldsha.

The cliffs of the Noup Head of Westray, 240 feet in height, appear to be of the same yellow rock. By Sir Rhoderick Murchison they are laid down as on the same horison as the strata of the Hoy hill-tops. There should in such a case be a great fault to throw them down over the thick beds of the flags in Rousay. No such fault is to be seen upon the shore; and, moreover, the igneous rock which in Hoy is seen to underlie the upper sandstones, is nowhere that I know of here present.

As the dip of the Noup Head rock is to the east, it may be one of the beds to be afterward noticed as occurring in the island of Fara; and if this be the case, the strata included between the beacon on North Ronaldsha and the Red Head in Eda represent the total thickness of the Old Red formation in Orkney; and, as it can be seen, by a section along Sanday, to be thrown into repeated folds between these points, that thickness cannot be great.

These red beds repose perfectly conformably upon the ordinary blue flags of the islands.

In Sanday the yellow beds are not of great thickness, they are conformable with the red, and at a spot called Heclabir are overlaid, also perfectly conformably, by thin beds of a conglomerate.

Observations made during two visits to this spot, and an examination of specimens brought therefrom, leave a strong impression in my mind that this is a *volcanic* conglomerate.

Its extent is small, being about 35 yards in length by 41 in width, and its total thickness is under 14 feet.

A fairly good section is exposed in a chasm of the rocks; as a road leads directly to the spot, this would seem to have been an old quarry. The stone may have been used as a burstone in mills.

The general dip of the rocks here is to N.W. by N., at the angle of 40°. The chasm has been cut at the angle of 30° ; an opposite affect to what would have been produced by sea-breaching.

At the bottom of the section visible at the locality, there are yellow sandstone beds with ripple-markings. Above these, six feet of sandy flags, very fissile at the top. Over this, one foot of sandy clay containing small pebbles lying in every direction: over this, one to two feet of green volcanic (?) mud, slightly wackenitic, also with small pebbles lying in every direction. There is next a few inches of sandy grit, capped by by about five or six feet of a tough conglomerate.

This conglomerate is made up of nodules considerably rounded, and of sizes varying from the size of millet grains up to that of the fist.

The rock-rents cut the pebbles, sometimes shifting them to the extent of an inch ; but I saw no pebbles in which the fractures were not connected with the rock-rents.

The conglomerate-cap shows false bedding in the layers of its pebbles, with occasional basin-like bands of grit.

The pebbles consist of *granites*, of more than one variety ; *gneisses* often chloritic ; porphyrys ; and seemingly of *quartzite* ;—rocks which are altogether different from the primitive rocks near Stromness, and therefore rocks *not occurring in the islands.*

Both the pebbles and the cementing paste have a highly vitrified aspect.

I have been informed that a conglomerate identical with this is to be seen on the coast-line at the south end of the Calf of Eday, which bears W.W. by N. ; and, at low water mark, on the shore of Eday, directly opposite to Heclabir, *i.e.* W.N.W.

Be this as it may, the conglomerate underlies a much thicker series of beds of the Red Sandstone ; these come in on the Island of Eday, forming its Red Head, and giving this portion of the series a thickness of about 1000 feet—the dip remaining much the same. The Grey Head of the Calf of Eday may be a local expansion of the yellow beds, but a fault may run between Sanday and Eday.

Yellow beds with an opposite dip are to be seen in the island of Fara.

Quarries of both of these coloured sandstones have long been wrought in the Island of Eday ; from these probably, the high-tinted stones of "the beautiful gate" of the Cathedral of St. Magnus, if not indeed of the whole of that structure, have been taken.

It has been stated that a narrow strip of older rocks occurs in the west of the islands.

This is, to the south, first seen in the island of Gremsa, of which these rocks form perhaps a fourth part ; it re-appears on the opposite shore of

the Mainland, extending in width from the Point of Ness on the west, to the mill-water of Cairston on the east,—probably about a mile. Thence it runs north for about four miles towards Inganess point, where it has thinned away to a breadth of a few yards, and where it is sharply cut off by a trap-dyke.

The exact horizon of the beds which repose upon the flanks of this wedge (they have been removed by denudation from off its surface) could only be ascertained by a careful section across the whole island.

This primitive belt consists for the most part of a fine-grained granite with a dark mica: towards the eastern side there is a tendency to a passage into syenite, while on the western there are gneissic beds, though of no great thickness, superimposed upon the granite.

Upon the west side of this mass there lies a conglomerate, gradually passing into a gritty sandstone. This conglomerate is formed of highly brecciated particles of the gneissose and granitic rocks; it is over-laid by flaggy beds which dip uniformly and persistently to the west, as far as the land continues.

The beds in contact with the primary belt upon the east also dip away from it for some space; but, at some points of the easterly contact, ferruginous argillaceous-flags are seen with a N.W. dip of about 8°.

The details of the section to the west of the belt of primitive rocks as seen on the sea shore in the vicinity of Stromness is as follows:—

Immediately at the Point of Ness—best seen at low water—there is granite possessing much of the features of granulite. This is overlaid by lepidomelane-gneiss which dips S.W. at the angle of 15°.

The beds of gneiss are very thin and are succeeded and overlaid by conglomerate, composed of fragmentary nodules of the underlying gneiss. This conglomerate has a thickness of only about 20 feet; its dip is as great as that of the gneiss, but it is to W.S.W.

The conglomerate is succeeded by argillaceous-flags, which are somewhat gritty when in contact with the conglomerate. The argillaceous beds are overlaid by ordinary fissile flags, up to a small bay near a life-boat house. There is now, however, a fault with a considerable upthrow, granite tending to eurite re-appearing. The granite is traversed by interlacing veins, and continues for a distance of 40 yards. It is succeeded by a conglomerate, which contains nodules of gneiss and granite—these nodules lie in all positions. This rock continues for 100 yards. It is overlaid by thin beds of a gritty conglomerate, to which there succeed flags containing plants, some of which were considered by Dr. Fleming to be fucoides.

These flags are succeeded by others showing many sun-cracks; while some beds are profusely sprinkled with rain-drop pittings. The dip of the beds which supervene upon the fault gradually turns to the west, while the angle of the dip, never so high as that of the beds eastward of the fault, is gradually diminished to 7°. These beds continue for half-a-mile, when they are succeeded by others of a finer grain, in which are entombed multitudes of fishes. These fishes are converted into a substance of a pitchy blackness, which but seldom retains more than the general form of the organism. In such as are sheathed in a bony carapace, the blue tint imparted by phosphate of iron is frequently observable.

In these beds *marcasite* nodules are rarely found, *calcitic* veins fill cracks which run south: Thin veins of *stromnite* occur both in the flags and in the conglomerate. Two trap-dykes with associated *lydian-stone* cut the strata from west to east.

The *lydian-stone* occasionally has a structure resembling fossil-wood.

The conglomerate rents are small: they cut the nodules rarely, but do not shift them.

Piecing together this evidence, and reading therefrom the record of the rocks, it is evident that, though in no place do we see the basement layers, the Orkney beds were deposited upon a very uneven bottom—the bottom, so far as Orkney discloses, of a shoreless sea—a bottom from which in one spot there protruded first a rocky gneissic islet, converted by a sinking land into a skerry-like ridge, against which the surf of a westerly-sea beat, so as to form a fragmentary shingle. That through the continued sinking of the land there had been deposited upon the conglomerate so formed, first, the muddy silts which, exposed to sun and rain, became the pabulum of plant life; and secondly, the still muddier deposits into which the remains of animal life sank and were entombed. Lastly, the dipping away of the strata from both sides of the supporting ridge,—and that at an angle which, in the immediate contact is higher than that which is normal to the series,—speaks unmistakably of local elevation and protrusion of that ridge, probably anteriorly to, but at least independently of the general elevation of the land.

As a locality of special geognostic interest, the coast line from the Bay of Skail half way to the Black Craig, on the west side of the Mainland, may be instanced.

The various points of interest along this shore are not only numerous in themselves and diverse in their nature, but they are also seen with very unusual facility; they moreover present themselves with very unusual clearness.

The locality is, in the first place, an open book of illustration of th *warfare of nature*—of sea and air sapping the foundations, and scalping th cornices of the bulwarks which confine the former in its bed.

These illustrations are very different in their mode of operation those noticed when speaking of the coasts of Shetland; *there* the assau was direct, and unmistakeable; here, on the other hand, it is insidiou and is carried into effect frequently by what may be called a flank mov ment.

This diversity in operation is due to the difference in the nature an bedding of the rocks. Here the strata, consisting of thin-bedded and u usually-fissile schists, repose in sheets, which are nearly parallel to the wav at their base; the dip being only 2°, and to the N. ½ E,—that is at righ angles to the line of coast. The seams of the rock are thus as open to t insinuation of the wave-wedges, as are the leaves of a book to the thr of a paper-cutter.

Again, the beds are cut at right-angles to their dip, by a series of tr dykes which have filled up pre-existent rents. These rents were mer the most widely-gaping of a system which cuts the rock with very u usual frequency. The slabs of rock thus lie almost unattached to o another in two directions, like a number of closely adjacent packs of car —ready to be displaced whenever the disrupting force is sufficient separate them by merely overcoming their gravity.

But gravity may even aid the displacement, should the circumstanc admit of its coming directly into play. At the southern corner of th Bay of Skail, the circumstances are such. Here two closely-adjace dykes have cut the interstitial beds loose from any but their own adhesio The surface-waters, playing upon the jointed and rhomboidal blocks, fir widened the open joints by their solvent soak, and then lightly lifte them out of their seats, towed them from the land, and thus graduall tunelled a low and deep-water cave between the dykes. As these cut promontory from side to side, the straight-sided tunnel so formed pass through the land, forming what is called the Hole of Rowe.

Heavier surfs and loftier surges forthwith lashed their spray against th roof of this low passage, opening out the rents between block and block, an between these blocks and the retaining igneous walls. Gravitation no aided the rending, and slice after slice of the sandstone was dropped int the waters, just as card after card falls from a horizontally held pack when the grasping fingers are gradually relaxed.

The falling in of the roof of this tunnel is but a question of time ultimately a *stack* of Rowe will appear,—the sides of the intervening chasm being sheathed with trap,—leading perchance to the false conclusion that dyke of unusual width had yielded to the assaults of the sea.

Doubtless it is on account of this unceasing widening of the horizontal crevices in flatly-bedded rocks, through the sap of the waters, that we so generally see a dip of these rocks away from the land and towards the sea,* whatever be the dip further inland. Gravitation closes up the open joint *pari-passu* with the widening,—folds the land prone to the waters,—till the *nodding* tears open a longitudinal rent, and the dissevered mass gradually "topples to its fall."

It has been said that the agents of destruction often operate by flank-attack; the cutting out of the Hole of Rowe has been indeed much of that nature, but a more decided illustration is in the near neighbourhood to be seen.

The cliff, marked in the Admiralty Chart as 180 feet in height, is capped by a shallow covering of turf, with underlying ochery-clay. The land rapidly falls landward to a hollow, scarce a hundred yards distant.

This slope is cut into wide and deep channels,—the beds of streams which must sometimes rush in brimful fury. But these channels commence but a few feet from the brink of the precipice; and the water-shed is so narrow that in the most rainy weather merely a trickling stream follows their landward course. Not so, however, when the Atlantic surges top the verge, and the overflow of the loftier billows, sweeping along in salt-water rivulets, fills them to the brim, and by rutting out an ever-widening channel, acts as a pioneer to the ordinary operation of the waves in cutting sea-stacks from the land.

Still another illustration of the battle of the elements is here to be witnessed.

Higher up upon the grass-clad banks, a gun-shot and more from the brink of the precipice, lying loose and lightly-poised upon the sward, there lie numerous flakes of stone. Around them, and between them and the sea, the grassy banks are all unbroken; the surges therefore did not lay them there,—but the wind, forcing itself wedge-like into the crevasses of the many-jointed and thin-bedded strata, had torn them from their beds and scattered them over the land like winter leaves.†

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* I am indebted to Dr. Joass, of Golspie, for *pressing upon my attention* this too-much disregarded fact,—it is far from universal, but is very general. The explanation is patent.

† The Revd. Dr. Clouston thus describes the aspect of an ordinary gale at this spot. "During a storm from the west the scene is awfully grand. The large accumulations of water that then roll after each other, foaming with terrible violence to the shore, impress the mind with irresistible power, and might well give a stranger a feeling of insecurity; and, when they dash themselves against the precipice, it seems half sunk, for a time, like a wrecked vessel amid the waves; sheets of spray are thrown far up into the air, and carried over all the country, making springs a mile from the coast brackish for some days, and encrusting everything with salt, even fifteen or twenty miles off. I

At some spots of the coast, the numerous joints and cross-rents of the rocks have produced an appearance much resembling a shattered tesselated pavement. Jameson, Fleming, and many older writers have noticed it.

In Wallace's "*Account of the Orkney Islands*" published in the year 1700, he thus describes the locality.

"At the West-end of the *Mainland* near *Skeal*, on the top of high rocks, more than a quarter of a mile in length, there is something like a street all set in red clay, with a sort of reddish stones of several figures and magnitudes, having the images and representations of several things, as it were, engraven on them; and, which is very strange, a great many of these stones when they are raised up have that same image engraven under, which they have above. This causeway is all along the tops of rocks, and though they be otherwise of a very considerable heighth above the sea, yet the West Ocean in a storm leading that way, does dash with such violence against the rocks that the sea breaches do wash the ground on the tops of the rocks. If these stones had not the same figure on that side next the ground as they have above, I should think the sea washing over them might occasion these different figures, by washing away the softish parts of the stone and leaving the harder, and so accordingly give them these accidental shapes and figures. Tho' there are a great many of them still remaining, yet the gentlemen living near that place have taken the prettiest figures to set their chimnies with, as they use to do in *Holland* with painted bricks and tiles."

Dr. Fleming, in the 8th vol. of the Edin. Phil. Jour., thus describes it.

"The strata have an inconsiderable dip, and consist of thin slaty sandstone, abounding with argillaceous and ferruginous matter, with minute scales of mica. The uppermost layer or even layers when exposed to the action of the atmosphere, aided occasionally by the spray of the sea, becomes divided into numerous tabular pieces, by means of vertical rents, and exhibits the appearance of mosaic work. These tables are irregular, but differ in the number and relation of their angles, although they sometimes exhibit regular geometrical forms. Upon the layer being thus

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am told by those living a few hundred yards from the spot, that the floors of their cottages are shaken by the violence with which the waves strike the crags. and I have seen innumerable sea insects alive on their summits, and even a limpet adhering to them after such a storm also numerous fragments of slaty stone, some of them a foot long, which had been whirled into the air, and had penetrated six inches into the soil in falling.

On the top of one of these crags I once picked up a lump of India-rubber covered with barnacles.

Not far from Rowe, is an immense rock which is well known to have been carried a considerable distance by the sea; it is 16 feet long, 6 broad, and 3 thick, and weighs, according to my calculation, 24 tons.

divided, decomposition speedily takes place. It proceeds from the sides towards the middle, and as the decomposed matter is washed off, the table exhibits a depressed border, marking the extent of the decay, having the middle raised, and consisting of unaltered matter. In some cases there is a well-marked groove, separating the two portions. In both varieties there are prominent irregular pieces of the rock, which seem little liable to decomposition."

To me there seemed to be a greater amount of regularity in the cleavages and angles than Fleming seemed to have observed. The rock almost always splits up into lozenge-shaped fragments. At one locality these were generally pretty uniform in size,—being 7 inches by 6; at another the general size was 6 inches by 5.

The averages of many measured angles of the lozenge were 109° 30′ and 70°30′—the greater angle varied from 106° to 114° the smaller from 67° to 72°30′. Dr. Fleming remarked that the number of angles differs. This would, however, appear to be due to the simple truncation of the acute angle of the lozenge.

The depressed border, generally of a bright yellow, is about an inch in width and is usually margined on its inner side by a trench and raised ridge, each differing in colour; there is thus produced a structure of singularly artificial appearance.

The splitting up of this rock and the manner of its weathering is assigned by Dr. Fleming to the action of the air and the spray of the sea; the splitting up of the rock at least might with greater probability be assigned to a certain amount of definite structure in the stone; and when it is observed that both the thick and the thin flags of the country show a general tendency to a rhomboidal arrangement between their strike and dip-joints, there can be little doubt that this is the true cause.

Indeed the very marked regularity and persistence of the jointing of these Orkney flags determines to a very great extent the marginal contours of the rock as a whole, and its endurance or decay under the influence of the agents which are free to affect it where exposed in the rock fringes which mainly gird the islands.

A long familiarity with the sea-cliffs of this formation, and a close consideration of those of other formations, has convinced me, *first*, that whether the agencies of decay operate singly or cumulatively, the rapidity of the decay, destruction, or local transfer, is to be assigned *far more to internal weaknesses*, either physical or chemical, than to external agencies. *Secondly*, that in our attempts to interpret the operations of nature, *there is far too great a tendency to ascribe change to the sudden and violent operation of the forces of convulsive effort,—to the almost total disregard of*

the gentler and continuous operations which, through their being protracted in time, come to be insidious in their workings.

That the precipices which girdle our shores are in one sense *sea-cliffs* is most true, but that they were all or to any great extent *sea-cut* cliffs is more than doubtful.

The sea maintains the perpendicularity of the cliff, it is true, by sweeping away the debris from the foot; but very seldom has the sea formed the cliff, by a continuous battering of the looser rock-layers at the summit; or by the breaching of an undercut recess at the foot, so that gravitation by the rent of a sudden fracture hurled the overhanging mass into the ocean. The rent was an open joint,—a component feature of the rock-structure,—independent altogether of gravitation's working, and while yet the sea was far off from that portion of the land.

On studying all the varieties of cliff which are to be seen in these islands, the observer will note that they group themselves into three forms,—that these forms are invariably associated with the dip of the strata,—and are only well defined if the dip is decided on the one hand, or if the stratum is horizontal on the other.

In those cases in which the dip is seaward, an outlying tidal-skerry with its wedge-like slope, forms a breakwater for the land; the surges are for the most part spent in force in the intervening channel; and but a low fringe of broken cliff protrudes from the land,—which, in such circumstances, thrusts itself beyond the usual line of the shore.

When again the dip is towards the land, a lofty precipice with step-like front, formed of the strike-joints usually at right-angles to the bedding, is the form assumed.

But the form which far most commonly arrests the eye, is a straight-lined and truly mural sheet of rock, which stands erect out of the waters, either directly in the general line of the shore, or projecting boldly seaward nearly at right-angles thereto.

Brief inspection shows that these sheeted, and wonderfully smoothly-cleft faces of rock are merely the joints of the stratum; longer inspection shows another set of open joints to run far inland at right-angles to the coast-line, and rents continuous with these or parallel thereto to succeed one another, with scarce any diminution in their frequency, till the sward conceals them.

These "backs and cutters" then—the shrinkage cracks of the rock—determine the nature of the frontlet of cliff. That the face of the cliff has been formed by a sudden falling away of outside material is evident,—that the material which fell was borne off by the waters is equally so,—but that the waves *by their battering* produced the fall, is far from evident.

The jointing is an element of weakness; in certain circumstances it may become an actual agent in the destruction.

Should these be any seaward dip of the stratum so that the strike-joints overhang, should these joints reach to the lower stratum, and should their frequency be such that the centre of gravity of any of the slices thus about to be cut from the land overhangs its base, then its fall is prevented merely by the molecular adhesion of its basement layers. This, feeble at all times, may be overcome by the vibration into which a single billow may throw the whole mass; or the wind may overwhelm it in a gale; or air-rotting may crumble its support.

Even indeed where the jointing is not so frequent or so close as to produce such toppling masses, they may be brought into a toppling condition by a process of wedging from above.

Near Hoy Head at a height of over 1000 feet, parallel to but far back from the cliff edge, long gaping chasms are to be seen, more or less filled with earth, clay, and jambed blocks of stones.

Into what was first of all a mere line of cross-cleavage, the entering air, by peroxidising the iron compounds, threw scale after scale from the mouldering rock, widening the crack above, and supplying material which hereafter would perform the function of a wedge. The process is one in which the operation progressed in ever increasing ratio of speed:—the downward progress of the rent opened a way for the operation of a water-wedge. Here the fashioning of the line of cliff, left to the operation of such agents alone, depends upon the relative amounts of the adhesion of the rock laterally and vertically. If greatest laterally, then will the wedge displace but a small depth of the stratum, dislodging it along the lines of bedding. If the bedding be not distinct and free, then must the wedge find a slow passage till the waters entering from beneath dislodge the material which plugged the rent.

In such a situation the waves could take no immediate, or at least primary part in the remodelling of the cliff; but it is not meant to be insisted on that the sea plays no part in the circumstances ordinarily obtaining.

There the ocean is ever lying in wait, surging and seething round the foundation-strata, sapping into every chink, and ready to spring at every weakened joint. Rushing with concentrated force up two closely-adjacent cross-rents it may lift out the intermediate blocks to make a widened *geo*, simulating a washed-out trap-dyke; or it may and often does remove the material of true dykes. No weakness can be hid from it; and, as the gales run round the different points of the compass, a crevice cut at right-angles to the first, allows the waters to meet those circulating in

it, and a quadrangular sea-stack now stands apart from the land. The waves, moreover, ever remove the debris of each fall, and so allow no prop to impede the continuance of the destruction.

But while thus admitting the part they must thus play, too much stress cannot be laid upon the assertion that the special conformation of the cliff-scenery of the Old Red Sandstone is due, as Geikie puts it, "not so much to the breakers (though their force is enormous) as to the less conspicuous action of atmospheric agents, which cut slice after slice from the edge of the land."

The situations in which among these islands the waters would at least appear to be the chief factors in breaching the land, are three.

First, water-floored caves; the second in the case of lofty projecting headlands, such at least as are not protected by a boulder-beach of stones; and thirdly, deep re-entering bights into which the waves converge as into a funnel, and up and over the converging cliffs of which they rush with heaped-up volume, and almost incredible might.

The first of these cases or localities are those in which a superficial observer would decline to accept the conclusion—that it was not the operations of the sea which had alone to betaken into account. I advert to those deeply-burrowing caverns—frequently with rounded, widened, and roofless terminations,—called *gloups* or *syngens*, in the language of the north.

As there is no part of Scotland in which there are so many or so fine illustrations of these, I take from the "Statistical Account" of the islands, and elsewhere, the following descriptions of such.

In the description of Westray, we read—"Here (Noup Head), besides many curious excavations in the apparently solid rock, are to be seen subterraneous caverns, formed by the influx and reflux of the sea. In some of these, the water at high tide, and in tempestuous weather is forced up through narrow crevices of the rock to the distance of nearly a quarter of a mile landward, and bursting out at the surface from orifices of its own formation, springs up in the air to a surprising height.

"Among the natural curiosities of the kind here to be met with, that called The Fort, evidently formed by the action of the sea, may not be deemed unworthy of notice. This remarkable place is situated on the northern boundary of that part of the island called Akerness. Here, standing upon a lofty precipice, you see, underneath, an immense cauldron in perpetual agitation, from which a hideous and gorging noise ever and anon ascends, stunning the ear. You can walk nearly half way round this mighty cauldron, on high pillars of solid rock, arched over with the same solid material. One or two broken or separated columns standing

out furthest in the circle, from which the arches seem to have been swept away by the agitated element, heightens very much the grandeur of the scene, and gives to it an appearance truly picturesque."

"On the north extremity, Papay Westray terminates in a headland, bold and lofty, called the Mull of Papay. At this headland, is a cave, deemed one of the greatest natural curiosities of the kind to be met with perhaps in all the country. Its interior presents the appearance of an immense amphitheatre. The roof, upwards of 70 feet in height, is somewhat like a regular built arch,—the beds of rock on every side rising the one above the other, in the form of steps in a stair. The entrance is about 50 feet in width, the breadth of the middle part about 60, and the most interior 48. The floor has a little inclination outwards, but its surface is smooth and even to the foot. It is called the How of Habrahelia."

"In the vicinity of Halcro Head, in South Ronaldshay, there is a remarkable cavity known as the 'The Gloop.' In a heath-covered mound, some two hundred yards or so distant from the shore, there is an opening like the crater of a miniature volcano, and far away down in the abyss you hear the sullen plunging, gurgling, and groaning of the imprisoned sea. The waves have excavated a long subterranean passage or gallery, which echoes with their thunder-boom in the day of storm."

"On the west side of Scalpa Bay, there is a cave called the Salt Pans, which runs parallel to the shore to the distance of twenty paces. The front has the appearance of freestone pillars, placed at irregular distances of about five feet. Above and below, and also behind these pillars, there are *rocks of harder stone*."

"At the Vat of Kirbuster in Stronsay, the sea has broken a magnificent archway through the front barrier of rocks, and, having once forced a passage the waves dashing and lashing through the archway for centuries, have formed an enormous excavation among the rocks behind, which being open to the sky, presents on a huge scale some resemblance to a vat. The archway may be likened to some work of massive Titanic masonry, and there is a wild sublimity in the hollow echoing boom of the waves as they bound from side to side of the arch, and break in foam within the mighty caldron of stone."

Similar to these are the "Syngens," near Scabrake Head in Rousay, and near Snelsetter, in Walls: in one of the latter, the communication with the ocean is always below low-water mark, notwithstanding which the mast of a vessel was once found floating in the land-encircled basin.

Other similar ocean-floored caverns have been noticed at Scraada, in Shetland, and in Fair Isle; and those of the Gellie Pot, near Arbroath, and the Bullars (boilers) of Buchan are well known.

In all of these, though the sea is directly the instrument of destruction, —as even the description of the Fort in the "statistical account" would indicate,—yet it is equally evident thatsome local peculiarity, conformation, or weakness of the rock, as directly accounts for the *exceptionality* of that destruction.

Where the sea penetrates it the extraordinary distance of "nearly a quarter of a mile" beyond the ordinary coast line, as vouched for by the pastor of Westray, there must have been some extraordinary softness or looseness, or facile-solubility in the mass removed. In this case, a crumbling dyke of trap, in that, columnarly-crevassed basalt, here, a soluble calcareous-seam, and there,—as at the Gally Pot,—a vein (baryte) with loose attachment to its walls.

So that in these cases, even more than in the circumstances which ordinarily obtain, we are brought back to the same conclusion—*inherent weakness* in the ordinary case,—*exceptional weakness* in the extreme cases.

The Bery Head in Walls, and the cliffs of Foula are instances of the second of the situations in which water would appear to have been the active trencher upon the confines of the land: here the sea by undercutting, may have induced a true rent from top to bottom.

Rackwick Little, and other points between Melfea Hill and the Bery on the west side of Hoy, are instances of the third. In the riven and crumbled rocks, the torn up turf, and the subsoil gashed far back from the cliff edge, the spectator will see evidence of the operation of some agent of terrific might; but when, he contemplates the height of the cliffs, he will be slow to believe that the waters of the ocean sleeping at their foot can have been so elevated as to have been that agent. Only the seeing them in the work of destruction, or the observing live limpets adhering to the summit of the rock after a storm, would help him to believe in so tremendous a displacement.

Yet in the ordinary case their effect is but small. Some estimate of the amount of its action may be arrived at from what the writer was so fortunate as to witness during a storm of unexampled violence which occurred in the winter of 1851.

The locality at which the effects of this storm was witnessed, was the Scabrake Head in Rousa,—one to which strangers visiting the island are frequently conducted to witness the spectacle of the ocean in wrath.

This headland consists of a mural wall of rock of about 120 feet in height, which faces the north-west. At the southern extremity of this extended wall there is a projecting bastion, termed from its form The Knee; from this, as it is thrust at right-angles to the main cliff some distance oceanward, the lash of the waves against the great wall, and the turmoil of the waters beneath can be viewed to advantage.

The cove between these opposing fronts of rock is a very place of storms: except in the calmest weather, the agitation is here incessant, and this is occasioned by two circumstances.

The first, that across the ocean, and right in front of this cove, the *röst* of one of the swiftest tidal races in the islands* runs with its curling waves and resistless rush of waters, in the very face of the incoming billows of the Atlantic. The second, that the moving mass of oceanic water, somewhat broken in its continuity and irritated into increased volume by the convergence with itself of the huge masses of the rollers of the *röst*, finds itself, as it enters the funnel sides of the cove, suddenly shot up from a depth of fifteen fathoms, to one of four. The result is that, there no longer being depth commensurate to the amplitude of its oscillation, it *peaks into a breaker*, and flings itself at the cliff with a volume and a violence which is altogether exceptional.

In an ordinary gale of wind then, there are four circumstances which here combine to enable the force of an ocean-billow to operate with extreme and abnormal violence.

There is *first*, the directness of the exposure to a mass of water of say 20 feet in height,† the undulation of which is rushing over the ocean surface at the rate of from twenty to thirty miles per hour.

Second, that undulation has to run diagonally across the rush of the waters of the tideway, which are moving in an opposite direction at say 7 miles per hour,—and it catches right in the teeth, and coalesces with the rollers of that tideway, which are as lofty as itself, though far from as ample.

Third, its waters come to be heaped up latterally, by the sides of a widely extending and converging V shaped shore.

Fourth, they are thrown vertically upward by the rise in the bottom, but there is still depth enough, and perhaps just depth enough for them to submit the cliff to the full concentration of the blow.

On the occasion refered to by the writer, a succession of westerly gales had continued for about eight days; on the morning of the last, the tide rose to a greater height than it had done for twenty-eight years, and the gale

* This Röst has thus been described by Gorrie in his "Summers and Winters in the Orkneys."

"Listen! and you hear a roar from the nor-west, as if the Atlantic were about to burst down upon us with the thunder and tramp of irresistible waves. It is the Roost of Enhallow, swirling, tossing, and boiling in the ebb-tide—a terrible sea-cateract from which unskilled navigators might well pray to be delivered; happily for us, our course did not lead us near the foaming lips and roaring throat of this Maelstrom of Enhallow."

† Dr. Scoresby measured, in the Hibernia Atlantic waves 33 feet in height. In the Royal Charter he measured waves at the Cape of Good Hope 45 feet in height. The highest wave which the writer measured during several months in the Atlantic was 21 feet.

raged with a fury which exceeded that of any within the memory of the islanders.

It is altogether beyond the power of the writer, if not beyond the power of language, to convey any idea of the spectacle which was seen from the summit of The Knee upon that day,—beyond saying that the violence of the blows which the cliff received, the height of the billows, the distance to which the broken waters were wind-borne landward, the size of the masses of flying foam, and the lashing and seething turmoil, altogether surpassed anything he had seen either there or elsewhere.

Though, however, description fails, some of the *actings of the waters* may be in bare language stated.

There was no regularity of motion whatever in the embayed water—it was a tortured mass which was twisting and tossing in an unceasing turmoil. Into this seething mass the greater billows would roll, as usual in sets of three; the upper waters of the first would spring back like a shower of snowy bullets discharged from the stricken rock; the back-tow of its recoiling mass would meet the upheaval of the second, and the united volume would spring aloft in a lighthouse-like form, level with or overtopping the main cliff. The third wave would throw itself headlong into the falling and subsiding vortex. So frequently did this happen, that it seemed to be worthy of consideration whether this habit of the ocean of rolling ever in three giant-waves, followed by a succession of minor wavelets, was not a provision for checking the power of the billows to rend the shores,—there being, in this mode of their action, a clear indication of self-destructive effort;—certainly so as regards this special locality.

But the rock did not always escape the full force of the blow of the greater wave, though during the time it was watched, it was so struck only some six or seven times. About one half that number of times, the wave was beaten back; the other half *it topped the cliff.*

With a seeming rush, as if it were pervaded with an actual intention, it would fling itself against the cliff and strike it in full force. On these occasions the shattered water shot up into the air erect, but in such ponderous masses that they were uninfluenced by the gale, falling vertically back to the spot from which they rose; these masses of water were thrown to a height apparently two-and-a-half times that of the cliff itself.

When it topped the cliff the spectacle was an inconceivably grand one. Like a solid but plastic mass, it curled over the verge,—a wondrously beautiful mixture of pellucid emerald, streaked with the purest white. The waters rushed with seemingly resistless force far up the land-slope—returned with a noise like the roll of many wheels, and fell back along

ıe whole extended line of the cliff, muddied and discoloured, bearing reat slices of the turf and stones,—a perfect Niagara of clay and water.

A somewhat similar development of power was seen at an adjacent ocality. A projecting tongue of land,—narrow, but eighty or one hun-red yards in length, 90 feet high at one end and 70 at its extremity,—ndlocks a bight, which, from its proving a safe shelter for boats in rdinary storms, is called Providence Geo.

On every other occasion in which the writer had seen it in a gale, its mbre waters were smooth as those of a mill-pond. On this occasion a long xtended billow, rolling towards its seaward side, suddenly erected self, rushed at the cliff like the charging front of a regiment of soldiers, -seemed hardly to touch the basement of the cliff, but flung itself with ırling cap right over the tongue, and fell into the Geo. In the Geo the aters were not greatly agitated,—a Cunard liner could have lain without uch motion, but the pent up foam would have been mantling over her ılwarks.

Such a storm as this has never occurred since—it was the spasmodic fort of half a century. And what did it *accomplish?* It has been seen hat it could *do*, but that was all froth and fury. *It did nothing in the ay of altering the old landmarks!* When the waves struck the cliff the low resounded like the discharge of far-off cannon, but the rock did not ıake:—the crest of the cliff when examined afterwards showed much ven earth, and scalped soil, with a surface clean-swept of stones; but o mass was disjointed, there was no rock rending. In a few summers ıe turf would grow again—has grown again; *the ocean battery had ccomplished nothing!*

Surely then we must conclude that the ocean is not the direct agent the fashioning of the fringes of the land; that the chisels which cut ıe huge bastions of Foula and of Hoy, rank with the ceaseless and the ırading grasp of oxygen, the expanding dislodgement of the summer's eat, the soak of the raindrop, the influence of the balmy dew; that they e the agencies of the calm, and not of the whirlwind and the storm.

Among the beds in the neighbourhood of Yestnaby there are some thin yers of limestone, sometimes impregnated with bituminous matter and diating *pyrite*, and one of these beds is possessed of a structure which believe to be unique.

In the localities in which I saw it, it appeared to have been somewhat ted upon by the weather, so that the peculiarity of its structure was lvantageously disclosed.

It could be raised in slabs a couple of feet in dimensions, by three t four inches in thickness. Its upper surface exhibited a *pustular* and *pitted* appearance. The pustules were the terminations of finger-lik projections of calcareous matter; the depressions were due to the washin out of the dark blue laminated silicious and micacious rock which fille in the interstices between the projections. These were about one and half inches in length.

When the laminated matter was uniformly chipped out from the cal careous, there remained a structure which *when inverted* bore a grea resemblance to the roof of a limestone cavern from which there depende a multitude of regularly-spaced stalactites of nearly uniform dimensions.

When the slabs were broken into fragments, these bore a mark resemblance to a number of elephant's grinders, laid so that the fan *presented upwards*. They are called the "horse-tooth stone" in the distri

When this calcareous band was fractured, it exhibited a structu similar in all respects to that of a stalactite—both the laminated structu of the dependent stalactite, and the circularly zoned and radiated stru ture of a transversely broken stalactite.

But the acuminated terminations of the processes which I hav compared to stalactite *project upwards*. Had they been dependent, the formation would have been most difficult of explanation; as it is, appears to the writer *inexplicable*.

The calcareous portion of this singular bed is of a dull ochery colour.

Sketches of this singular structure are given in Plates XIV & XV The one shows the mastodon-like appearances of the cross fractures; th other the aspect of the surface of the bed. The hollows with the volcani like cones are the calcareous portions, doubtless dissolved out somewhat and leaving a harder or less soluble core.

The interest connected with the trap-dykes of this locality lies in the ver different nature of their lithological composition. Seven dykes are to b seen between the Bay of Skaill and the granite of Inganess.

Of the two which are closely adjacent at the Hole of Rowe, the more northerly shows merely crystals of *augite*, imbedded in the usual labradori and augitic doleritic paste, the other contains in addition much *olivine*.

The three which follow have a direct magnetic east and west course The first shows augite with imperfectly developed *zeolites*. The next is of a dense structure devoid of imbedded crystals, and has a highly-marke blue colour. The third is a ringing clinkstone.

The dyke which follows exhibits a marked departure from that recti linear course, which characterises the great system of Scotch dykes. From a W. by N. it suddenly curves round to W.S.W. course, and as

suddenly regains its original direction, exhibiting thus a bold sigmoid flexure: its structure is amygdaloidal.

The seventh dyke, which cuts off the granite to the north, is almost white in colour from excess of its felspar, and minutely cryptocrystalline in structure.

Jameson mentions another dyke, (of this I however only found loose fragments), namely, one containing "crystals of hornblende more than an inch long by half an inch broad." These crystals are of a grey brown colour, and very lustrous,—the cleavage seems to be that of hornblende, but I failed in my endeavours to pick it sufficiently pure for analysis.

These dykes vary in width from two to about ten feet: the small distance to which the rock is indurated on the contact surfaces,—about a yard,—is much the same at both the narrow and the broad dykes.

The southern front of a cliff near to the Hole of Rowe exhibits an interesting mass of stalactite: the calcarious waters have found their escape solely at one spot of the surface of a single stratum of the rock, about forty feet over the face of the cliff. From the open bed of this, the concreted masses twine in wavy curves downward, like the curlings of a huge beard.

As the rock approaches the termination of the granitic masss at Inganess Point it becomes less argillaceous, till at one headland it is of the nature of a grit, and has been to a small extent quarried for millstones. As regards its hardness and toughness it is well fitted for such, but it is hardly of a sufficiently coarse grain.

The immediate locality where the granite terminates well deserves a close inspection, as it is a locality which will probably throw some light upon the metamorphism of gneiss into granite,—there being little doubt that such a change has here occurred.

From an angle in the shore-line the rocks have been exposed in cross and also in longitudinal section. A sketch has been appended. (See Plate VIII.)

The long wedge of granite previously described, seems to have nearly thinned off immediately to the south of a trap-dyke; but the sea has intruded here, so that at the spot where the central rib of granite presents itself, this cannot be absolutely determined.

On the north and south cliff-line a white trap dyke, which runs nearly at right angles thereto, separates the horizontally-bedded grit from a shattered mass of granitic-gneiss. The westerly continuation of this dyke shews itself as a small sea-stack, and it thereafter cuts the same gneiss which at Stromness is seen to overlie the granite.

The central rib or core of granite which fronts the trap-stack is amorphous, and is rent by promiscuously disposed fissures; but to the west it becomes distinctly bedded and slabby, before it passes into laminated gneiss. The slabs dip to the west. In the central part of this east and west section, a conglomerate, formed from gneiss, passing upward into gritty flags, overlies the gneiss, with a dip to the north.

The gneiss which is cut by the dyke is much altered for four or five feet at contact, but it does not appear to have been faulted.

There is a small amount of disturbance both in the sandstone and the granitic-gneiss where it cuts the bank, so there probably is here a small fault which dies out to the west.

From the grit coming-in immediately to the north, the upthrow must be but small; but that a fault really exists may be deduced from this that there is no continuation of the granite north of the dyke along that which is its medial line: it is seen at Steinicknow in mass, and if it were not cut off it should appear (which it does not) still further to the north.

Turning the western point of Inganess, we find at a short distance south, the ordinary rhomboidal-jointed blue-flags reposing with a westerly dip upon the gneiss; and these blue-flags continue, with occasional parallel dykes, southward to the Point of Ness. They reach their greatest height at the Black Craig; and either here,—at Costa Head,—or at the hill of Blotchinfield in Rousa, we must have the greatest thickness of the blue-flag formation in Orkney.

The dip to the west of the strata which on that side are in immediate connection with the gneiss at Inganess,—the dip to the north of the strata lying northward of it,— and the continuation of that northerly dip as far as Rowe, lends additional countenance to the view that the islet of primary rocks had been subjected to local elevation, independent of the general elevation which raised the whole basin of the sandstones above the waters.

Dr Clouston remarks—"On the east side of the granite, it is only the strata in immediate contact with it which dip east; for, in the course of 100 yards, they gradually dip more in conformity with the general dip of the country; but they may be seen dipping east on the shore of Græmsay, and at the point of Garsen, in Stromness; and again they dip north-east at the Burn of Cairston, and at the north-east boundary of the granite."

The strata thus dip away from the granite and gneiss on every side, unless it be on the southern extremity; and the first of Dr. Clouston's observations points *almost conclusively* to there having been an upward thrust of the granitic islet after the schists had consolidated upon its flanks.

Taken in conjunction with the general dip of the whole series to the west, as first seen in Stronsay and last near Cairston, it shows also that the Stromness flags are far up in the series,—that the granitic reef protuded long above the waters,—just as, away to the westward, the Stack and Skerry do so still.

Now this is exactly the conclusion which has already been arrived at by Professor Geikie from a consideration of the Hoy sections, as will be noticed further on.

NORTH RONALDSHAY.

In this low-lying island the rocks show but two varieties—the flaggy and the argillaceous.

The flags have been wrought in a quarry at the north-eastern end of the island. They are of somewhat tougher consistence than the flags of Caithness,—are less bituminous, and cannot be split into such thin slabs.

They can be raised here probably of greater size than at any other quarry in the islands.

A dressed slab, which of itself went a long way to form one side of th roof of a cottage, was found upon measurement to be 14 feet long by 8 broad, and about 2 inches in thickness.

The dip in this quarry is to the east, at a low angle ; but east and wes dips are equally frequent, and would in some spots at least appear to be in some degree connected with the disturbance caused by dykes whic have no connection in any way with the great west and east system o western Scotland.

I was much struck by observing that the chief material of these dykes, which generally cut the strata at right-angles to the line of the dip, consisted in chief part of *limestone*,—indeed most frequently of *calcite* in large cleavable masses. So preponderating, indeed, is the quantity of lime relatively to the other material of the dykes—a soft green tufa—that it cannot be regarded as an exfiltration therefrom ; and we are almost forced to the conclusion that the calcarious matter had itself been erupted in a fluent condition.

The amount and nature of the surrounding disturbance, putting out of account the adhering tufa, altogether and alone precludes the view that there are pseudo-dykes,—the result of exfiltration into a tear or cross-rent.

So interesting are the appearances, that I thought it desirable to obtain independent evidence, and I therefore requested the proprietor, Dr. Traill, to favour me with a description of one of the largest of the dykes.

Dr. Traill is a most observant naturalist, and a careful recorder—he writes :—"The position of the limestone at Howar is on the shore below high-water mark, about a quarter of a mile south of the house, or S. by E. It seems to be an erupted mass of crystalline limestone, in some parts largely mixed with fragments of the blue flagstone, through which it appears to have forced its way. Length about 65

paces,—its direction S.S.E. by N.N.W., extending at the northern extremity perhaps half as far again in several small indistinct veins. Greatest breadth about 6 feet, but mixed with fragments of flagstone or shale, or impure blue limestone. The greatest breadth where it is comparatively pure or unmixed (calcite) is about two feet or rather more. Perhaps the average breadth of the extended mass is between $3\frac{1}{2}$ and $4\frac{1}{2}$ feet, but the measurements are only approximative on account of the admixture of other rocks. As I have said, it tailed off indefinitely at the north end, but at the south it came to an abrupt termination on account of the rock ending there. The position of the strata is there much disturbed."

The shelving rocky shores on the west of this island afford illustrations of the manner in which the Atlantic surges tear from their connections. and transport huge masses of rock.

The illustrations differ here in their nature from those noted in Shetland; they may not be so astounding, but they do not yield to them in instructiveness.

In speaking of the huge blocks of stone which on the coast of Shetland hang toppling on the verge of the cliff, I said that they had been *flung* there by the surge: all the circumstances of their position convey the impression of a sudden and supreme exertion of force; those to be seen on the shore of North Ronaldshay again convey the impression of transference by flotation. The first are in fact *perched* blocks,—the latter *transported* masses. The difference in the character of the shores accounts for the difference in the mode of projecture.

Here, the dip being at a gentle angle to the west, the flaggy shelves form a most perfect breakwater:—the smooth surfaces oppose no roughness, and no broken face which can receive and be shattered by the force of a blow. The curling billow, after its first crashing fall, sweeps unresisted in hissing and creaming foam, like a gradually thinning wedge, far above sea-level. The polished rock-surfaces in no way oppose the upward rush, in its vain fight against gravitation. The same gravitation which sweeps the undulation in speedy course along the ocean-level, calls back all individual particles which have transgressed the limits thereof.

As the rock is of two and a half times the gravity of water, a mass of 0250 tons weighs but 150 while held in its grasp; and the tremendous pressure *a tergo* more than counterbalances the difference in gravity; so that every loose mass which presents a surface sufficiently broad in comparison to its weight, is floated off and onward, bouldering along

the unimpeding floor, until some portion of its thickness, by protrud ing upward through the thinning water-wedge, has *its superadded w weight* lodged upon its shoulders, to sink and settle it upon th bottom.

No second billow, unless it be one of a greater storm or at a muc higher tide, can again float it; so that of the many shifted masses upo a shelving shore, few have had more than one dislodgement and shor ward rush.

It has been assserted that there are no raised-beaches in Orkne Several localities may however be pointed out where the sea can b shown to have stood for some time at a higher level than it does a present; while there are also numerous localities which prove a m very distant subsidence of the land. Of the former of these, tw exist in North Ronaldshay.

Immediately to the south of the lighthouse, there are to be observe winding trenches depressed considerably below the general surface o the island; these trenches have rough and craggy sides, their botto being strewn with loose stones. They bear a most perfect resemblan to the channels of lanes of water left by the retiring tide.

The other locality occurs at a point or turning of the north-we shore. Here, at some little height above high-water mark, there is flat, beach-covered, for a space of about 100 yards in length, with hug tabular masses of rock, undistinguishable, in appearance, form, an relative position, from those which are, in the near neighbourhood, t be seen on the shore at low water.

Dr. Traill thus writes of them. "They look at first as if they ha been tossed up by a mighty tempest; but as many of them were a least 10 feet long, by 6 or 8 feet broad, and 2 or 3 feet thick, I fel inclined to doubt whether it was possible that they could have bee tossed up by the sea, on such a shore;—and, on examining them mor closely, I was more confirmed in this doubt by observing that severa of these rocks were covered with grey lichen of considerable length particularly those masses which are nearest to the sea. From this i would appear that the sea rarely if ever reaches to so high a level except perhaps an occasional dash of spray in winter."

On the southern side of a picturesque geo about the spot where the crags are highest, concretions, probably investing some organism o coprolitic matter, are to be found; they much resemble a potato in size colour, and form. Their internal structure is obscure—the investing rock-layers curve round them, in infolding them.

Jasper or a jasper-like chert is the only mineral body I have seen in this island. It apparently, from the line in which I observed loose masses of it, forms veins ruuning nearly N.W. and S.E. Its structure is very close and fine. It is usually of a bright yellow colour, with occasional heliotropic patches of a vivid green, both colours being disposed in a minute moss-like arrangement. Veins of pale-blue quartz crystals ramify through it.

ISLAND OF SANDAY.

Apart from the occurrence of the red and yellow freestone beds on the western shore, and the conglomerate of Heclabir, the chief point of interest as regards this island is connected with a boulder of gniess which lies imbedded in the soil of a field which slopes to the east, about 200 yards west of the house of Saval, and about 45 feet above the sea.

The writer is indebted to the Rev. Mr. Fisher of the parish of Cross for sending the following measurements of this stone.

"The boulder which lies N.E. and S.W. in the direction of its greatest length is of uneven shape. It is embedded in earth to a depth conjecturally of 2½ to 3 feet. Its circumference at the level of the surrounding earth is 24 ft. 3 in.; but, as it appears to shelve out under the ground, its circumference may considerably exceed this.

Its greatest height (above the ground) is at one end 2 ft. 6 in., at the other hardly 2 feet."

It appeared to me that the greater part of this stone lay underneath the ground; and, from the slope, that if dug round its greatest length would prove to be from east to west; its greatest height is to the west.

This does not appear to be a British rock. It consists in greatest amount of white finely-striated *oligoclase*, the crystals of which are penetrated by fine filaments of actynolite,—glassy quartz in much smaller amount,—dark green finely-foliated lustrous hornblende, in well marked crystals,—very little of a pale-green mica,—a minute amount of crystals of a pale brown mineral, which may, but does not appear to be *sphene*,—and a speck or two apparently of *thorite*.

The mass also contains a single crystal of pale-green *apatite*, five or six inches in length by over an inch in width; and this apatite contains imbedded *cryptolite*. The oligoclase has occasionally the moonstone lustre.

The only Scotch rock I know which has any resemblance to this, is the gneiss which occurs, with a N.E. dip, on the N.W. slope of Ben Spinnu, in Sutherland;—this however, has orthoclase as its felspar, and does not contain apatite.

The rock has much resemblance to a Norwegian one, and, if it has been brought on floating ice, the carry most probably was from the east, or north-eastward.

ISLAND OF EDAY.

In this Island the yellow and red upper-beds attain at the Red Head, which is somewhat more than 200 feet in height. a greater thickness than at any other point in the islands, unless it be the south shore of Scalpa Bay.

A boulder, which lies on this island, is described in the "Reports of the Boulder Committee," which are published in the "Proceedings" of the Royal Society of Edinburgh.

ISLAND OF WESTRAY.

The situation of a large stone called the Earne's Cup, was pointed out to the writer from a distance. It lay on the NNE slope of the Neuker Hill, near Pierowall. This probably is a boulder.

ISLAND OF ROUSAY.

This island consists almost entirely of beds of argillaceous flags; these attain here to a greater thickness than in any of the other islands; its highest hill being about 811 feet in altitude.

So horizontal is the bedding, so thin the beds themselves, so step-like, that it has been said that in order to walk in the island, the pedestrian would require to have a long leg and a short one.

The hills of the island, arranged in horse-shoe form, show little diversity in their rocks: at the mouth of a stream which flows from two central lakes, the rock is somewhat slabby; while at one point about a mile south of the point called Scabrake Head it is more arenaceous, the silicious grains being united by much *sideritic* matter.

At the shore below the house of Westness, it is so much jointed and indurated as to form almost a tesselated pavement.

Perhaps the finest piece of cliff scenery in the whole of the islands, though it be on comparatively a small scale, is the headland above mentioned. Here a geniculated prop stands like a flying-buttress thrown with wide-spread span apart from the main body of a mural cliff. A crush with a tilt in the bedding may be seen at the very point of the geniculation. A dyke which cuts off the southward continuation of the prop, may have had some share in troubling the stratification.*

* Mr. Gorrie seems to think that it may come to be the source of other and greater troubles, for he writes,—"There are volcanic indications about the island of Rousay, and the inhabitants need not be greatly surprised although they should find themselves and their belongings tilted up fifty or sixty yards, some fine morning before sunrise." Notwithstanding the precision of this prophecy, both as regards time and space, we would venture to assure the islanders that the foundations of Rousay are somewhat sounder than Mr. Gorrie's geology.

Scabrake Head.

This dyke is of a soft porphyry, which contains well-formed crystals of *augite* (H) of the size of peas, in the simple form depicted.

The hill faces, and corries about a mile north-east of this, contain *galena* in well formed cubo-octohedral crystals (H.)

Ichthyolytic schists, opposite an outlying stack called the Lobust, contain *bitumen* of the consistance of tar. (H.)

This is one of the best fossil localities in the islands.

About midway between the houses of Westness and Viera Lodge, a vein with a fine granular barytic gangue, very similar to that of the Fair Isle, carries *malachite* with *azurite*, and apparently small quantities of *Smithsonite* and *pyromorphite*.*

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* Through the courtesy of Col. Burroughs, the proprietor, I am able to subjoin analyses of the galena and "copper ore." The first by Dr. Macadam, the second by Mr. Andrew Aitken.

The galena yielded Lead, 79·572; Silver, ·047; Antimony, ·014; Copper, ·013; Sulphur, 12·352; Gangue 8·002. As this percentage of silver is equivalent to over 16 oz. to the ton, this comes to be a most valuable ore.

The "copper ore" yielded—

Copper	3·03
Copper Oxide	3·75
Zinc Oxide	1·15
Lead	·76
Iron Oxide	5·5
Baryta	27·08
Lime	3·72
Arsenic	1·4
Sulphur	4·55
Sulphuric Acid	6·54
Carbonic Acid	9·65
Water	·60
Gangue	31·2
	98·93

This (of course presented as a mere commercial analysis,) affords hardly sufficient data whereon to speculate upon the grouping of the components. It however gives some ground for supposing that what I had from ocular inspection set down as Smithsonite, is *calamine*; and what I supposed to be pyromorphite may be the much-rarer *mimetite*.

"Concretions," similar to those of North Ronaldshay but of larger size—some singularly resembling the cast of a human foot—have been sent from this island to the Industrial Museum in Edinburgh, by Col. Burroughs.

ISLAND OF STRONSAY.

From Dr. Neill's "Tour through Orkney and Shetland," the following extracts are made. "Upon the north-east shore of Stronsa, near the Ness of Odness, there is a very large bed of shells, which I was assured was thrown up by the sea in the course of a single stormy night about twenty years ago. The shore here is very rocky, and the people say that, till that event, it was a rarity to find on it any kind of shell. Upon examining the bed, I found that a great proportion of the shells consisted of single valves of the *arca glycimeris*, of uncommon size, twice the size of Pennant's figure of the shell. Besides the aca, I picked up many water-worm and broken specimens of *ostrea maxima*. Neither of these kinds is to be found recent on the beach.

Between the Ness of Odness and Kerbuster, there is a large bed of limestone, the inclined base of which is washed by the sea. It is of a bluish colour, but not very rich, containing probably not fifty per cent. of lime in some places; however, it is traversed by broad veins of calcareous spar. This bed of limestone lies between strata of coarse sandstone-flag, with which it is in immediate contact both above and below, though marked by a well-defined line.

"A little way from the Brough, we saw the prodigious effects of a late winter storm: many great stones, one of them of several tons weight, had been tossed up a precipice twenty or thirty feet high, and laid fairly on the green sward."

ISLAND OF SHAPINTHAY.

Many trap-dykes cut the strata at the south east end of this island, having a magnetic east and west strike. A very limpid *naphtha* (J) occurs in small quantity in some of these.

XVIII.—*Experiments on the Elasticity of Crystals.*

By John Milne, F.G.S., Yedo.

WHEN we look at a collection of crystals we see that they can be divided into groups according to their symmetry. Thus, one group the members of which form the cubical system, have a symmetry in three directions at right angles to each other; that is to say we shall find similarly arranged planes at the extremity of three properly chosen axes. In other groups the symmetry is not so perfect. Thus, in the tetragonal system we find that the symmetry in the direction of the principal axis is different to the symmetry in the direction of the lateral axes.

When we see a crystal which seems to shew a similar symmetry in three directions, we naturally imagine that the molecules in their arrangement along these directions followed the same law. If, however, we have two directions in a crystal which as compared with each other shew differences in symmetry, we should expect that the molecules in these two directions had been arranged differently.

From what we know of the physical characters presented to us by minerals when examined in various directions, this view seems to be borne out. Thus Mitscherlich has shewn us that the dilatation of a crystal by heat has an intimate connection with its symmetry; if the symmetry is the same in three directions, the dilatation is the same in three directions, but along directions where the dilatation is different the symmetry is also different. De Senarmont has shewn us a similar relation for the conductivity of heat. The manner in which light is transmitted in different directions through a crystal depends on its symmetry, and in accordance with the laws which govern the passage of light through a crystal,we have the laws for electric conductivity. Tyndall and Knoblauch have shewn us that the magnetic and diamagnetic properties of a crystal have a connection with its symmetry. Or in short we find similar phenomena exhibited in a crystal along similar directions. Now if we accept the popular hypothesis of a crystal, that it is a body formed by the mutual attractions of molecules which are separated by an elastic medium, in order to more fully appreciate the above coincidences, we should be greatly assisted if we could shew that along the directions which in any crystals exhibit different phenomena, that there was also a difference in

material elasticity, which probably means a difference in intermolecular space or a difference in density. The chief experiments which have a direct connection with the material elasticity of crystals, are those made by Savart, who shewed that the figures formed upon vibrating plates of crystals were directly connected with their optical axes. Lately, I have endeavoured to shew that the material elasticity in a crystal was different in different directions, and at the same time to give some idea of its relative values by bumping together spheres cut out of calcite and quartz.

As these experiments have not given definite results, because of my not being able to obtain proper materials to be experimented on, and subsequently in not being able to get these turned into true spheres, the results which I now give must only be regarded as indicating what may be obtained when similar experiments are made under more favourable circumstances.

The experiments were as follows :—

I *Series of Experiments.*

The first experiments were made with a small ball of Iceland Spar having a diameter varying between 23·7 and 23·8 millimeters, and a ball of pure quartz with diameters between 26·0 and 26·1 millimeters. The ball of calcite was placed at the lower part of a cycloidal groove. The quartz ball was then allowed to roll from a fixed point down the groove and strike the ball of calcite. This was repeated, striking the calcite each time at a different point. Although the calcite ball was observed in consequence of being struck to roll different distances, indicating that these might be due to differences of elasticity in different directions, the experiments were too crude to be worth noting.

II *Series of Experiments.*

These experiments were made with the same balls as the first, and were very kindly carried out for me by the students of the Physical Laboratory, under the superintendence of my late colleague Prof. Ayrton.

The calcite ball was fixed in a piece of wood. The quartz ball was suspended by a silk fibre as a pendulum 6 ft. $5\frac{3}{4}$ in. long, in such a manner that when it was at rest it just touched the calcite ball.

The quartz ball was next drawn back $3\frac{1}{2}$ inches and allowed to swing against the fixed ball of calcite.

In consequence of this the swinging ball was reflected back a certain distance. This distance was observed. By repeating this experiment on several points of the fixed ball the reflection was found to be different. On the fixed ball fifteen different points were struck by the pendulum and each of these six times. The following table gives the mean result obtained for each of these points, arranged in order according to the deflection—

1.	1·54 in.	9.	1·28 in.
2.	1·46 ,,	10.	1·25 ,,
3.	1·42 ,,	11.	1·25 ,,
4.	1·33½ ,,	12.	1·25 ,,
5.	1·33 ,,	13.	1·25 ,,
6.	1·33 ,,	14.	1·25 ,,
7.	1·33 ,,	15.	1·16⅔ ,,
8.	1·33 ,,		

The points which were struck were chosen indiscriminately, but in the above table they are arranged according to the deflection.

The following are approximately diametrically opposite to each other; 1 and 2, 12 and 14, 12 and 15, 3 and 6, 11 and 12. From these it will be seen that, as might have been expected, in diametrically opposite directions approximately similar results were obtained.

A direction of no double refraction is approximately in the direction of the diameter 1 and 2.

Although it might be possible to deduce more conclusions from these results, I will not lay stress on them, as the method of experimenting was not altogether so satisfactory as could be wished, as the calcite ball between each series of experiments was refixed, it is exceedingly probable that this was not done each time in exactly the same manner, and in consequence it would not have been always in the same position to reflect the ball of quartz.

Notwithstanding this, the results are very significant of differences in elasticity.

The chief point to observe is, that in a direction of no double refraction the greatest deflection was obtained.

III *Series of Experiments.*

In these experiments, the ball whose elasticity was to be determined was placed upon a billiard table, and was there struck by another ball suspended as a pendulum.

The pendulum was a polished ball of quartz whose diameter varied between 36·8 and 36·9 millimeters. At diametrically opposite points

In this ball two small holes were bored in which two small brass pins were placed. These were used as points of attachments for two pieces of silk thread, the other ends of which were attached to two points 10 centimetres apart, affixed to a horizontal bar of iron above the billiard table. These were of such a length that the ball hung 65 centimetres below the iron bar. Being thus suspended it could be swung backwards and forwards without any movement of rotation.

The ball which was experimented on was of calcite; it varied in diameter from 35·2 to 35·3 millimeters.

In the first series of experiments the swinging ball was drawn backwards three inches, and then allowed to swing suddenly forwards and strike the ball of calcite.

The distance to which the calcite ball rolled was then measured, when the calcite ball was struck at different points it rolled different distances.

The points taken were as follows:—

First 1 and 2. These were diametrically opposite.
3 and 5 ditto ditto ditto
4 and 6 ditto ditto ditto
7 was placed half-way between 3 and 1
8 ditto ditto 4 and 1

Deflection in Centimeters.		Mean.	Mean.
1.	22 —22·5—22	22·1	21·8
2.	23·5—21·5—20	21·6	
3.	20 —21·5—	20·7	20·6
4.	20 —21 —20	20·5	
5.	21·5—22 —19	20·8	20·4
6.	20 —20 —20	20	
7.	21·5—21·5—21	21·3	21·5
8.	21·5—22 —22	21·8	

In a second set of experiments the deflection given to the pendulum was four inches.

Deflection in Centimeters.		Mean.	Mean.	Mean.
1.	37—40—42	39·6	39·8	
2.	39—39—42	40		
3.	37—36—33	35·3	36·7	36·8
4.	37—41—38	38·2		
5.	34—34—34	34	37	
6.	40—40—40	40		
7.	41—36—37	38	39·1	
8.	41—40—40	40·3		

The points 1 and 2 approximately give the direction of the opt axis, whilst the points 3, 4, 5, and 6 approximately lie in a gre circle of which 1 and 2 are the two poles.

Looking at the above table we see that in all cases when t ball was struck in the direction of the optic axis, that it rolled furth than when it was struck at right angles to this direction. When was struck in the direction 5 or 6, both of which are positions inte mediate to the direction of the optic axis, and the great circle 1, 2, 4, the rolling was intermediate to that given by the other directions.

These series of experiments were open to several errors.

First, the ball of calcite was not perfectly spherical. However, the points which were taken were diametrically opposite, the obser tions ought in part to balance each other.

Second, the line joining 1 and 2 only roughly represents the dir tion of the optic axis.

Third. the points 3, 4, 5, and 6, are not in the same great circ thus 5 is nearer to 2 than to 3 and therefore we could not exp them to give the same deflection.

IV *Series of Experiments.*

These experiments were conducted in a similar manner to the thi series. The balls which were used were the same as before, the calci ball however being re-ground and being brought into a form mo truly spherical. On this ball seven pairs of points diametrical placed were chosen. The diameters measured between these poin and their relative distribution was as follows—

	Millimeters.	
1. and 2.	33·6 ..	Approximately the line of the princip axis of the crystal.
3. — 4.	33·8 ..	These four points were in a great circ at right angles to the line joining
5. — 6.	33·9 ..	and 2.
7. — 8.	33·9 ..	8 lay between 1 and 3.
9. — 10.	33·7 ..	9 lay between 2 and the middle poi of the arc. 5, 4.
11. — 12.	33·7 ..	12 lay between 1 and the midd point of the arc. 6, 3.
13. — 14.	33·7 ..	13 lay between 2 and the middle poi of the arc 5, 3.

The deflections obtained were as follows—

			Mean.	Mean.
1.	22 —22·5—23	22·5	23·05
2.	25 —21 —25	23·6	
3.	21 —21 —21	21	20·9
4.	21 —21 —20½	20·8	
5.	20·5—22·5—22	21·6	21·6
6.	22 —21 —22	21·6	
7.	21 —24 —21	22	21
8.	21 —19 —20	20	
9.	21 —21 —22	21·3	22·3
10.	23 —23 —24	23·3	
11.	20 —22 —22	21·3	21·6
12.	22 —22 —22	22	
13.	25 —24 —21	23·3	22·3
14.	22 —22 —20	21·3	

In a repetition of these experiments it was found—First when the quartz ball was deflected three inches, the roll of the calcite ball was as follows:—

		Mean.	Mean.
1.	25—25—25	25	24·7
2.	23—25—25	24·4	
3.	20—21—21	20·6	22·1
4.	23—23—25	23·6	
5.	23—23—24	23·3	23·3
6.	25—22—23	23·3	

Secondly, when the quartz ball was deflected four inches—

1.	29—26—26	27	28·1
2.	28—29—31	29·3	
3.	27—27—27	27	26·6
4.	26—26—27	26·3	
5.	25—25—28	26	26·1
6.	28—25—26	26·3	

For the total roll in diameters of the calcite ball in all these experiments, 9 must be added to each of the above numbers.

It may be remarked that points like 11, 12, 13, and 14 were the most dented by being struck with the ball of quartz, whilst the other points did not shew any signs of the blows they had received.

In these experiments it will be observed that the same general results have been obtained as before, namely, that when the calcite ball was struck in the direction of the principal axis of the crystal there was the greatest deflection.

In any direction at right angles to this there was the least deflection, and at intermediate points deflections of intermediate values were obtained.

V *Series of Experiments.*

These experiments were made upon two balls of rock crystal, the one which was used as a pendulum being the same as the one in the last series of experiments.

The ball which was struck had diameters 36·7 and 36·9 millimeters.

On it a number of points were taken marked from 1 to 11 consecutively. The pendulum was deflected three inches, and each of the above points were struck three times.

The distances rolled by the ball which was struck are given in the following table—

						Mean.
1.	40	—	42	—	42	—	41·3
2.	42	—	43	—	43	—	42·6
3.	40	—	40	—	41	—	40·3
4.	44	—	42	—	42	—	42·6
5.	43	—	43	—	43	—	43·0
6.	40	—	41	—	43	—	41·3
7.	40	—	42	—	43	—	41·6
8.	39	—	42	—	41	—	40·6
9.	42	—	39	—	45	—	42·6
10.	43	—	40	—	44	—	42·6
11.	40	—	44	—	43	—	42·3

The following points were approximately diametrically placed, 1 and 4, 2 and 11, 3 and 6, 8 and 4.

On looking through the quartz ball at a pin hole in a card in diametrical directions through the points 1, 3, 4, 5, and 6, no double refraction was observed. In other diametrical directions through the remaining points, double refraction was observable.

All that can be said with regard to these experiments in a ball of quartz, is that it apparently shews different elasticities in different directions.

Conclusion.

From the above experiments it would seem to be shewn that crystals have different material elasticities in different directions. In the case of a ball of calcite, the greatest rolling effect was obtained when it was struck parallel to the principal axis of the crystal.

In a direction at right angles to this the least effect was obtained, and in intermediate directions, intermediate effects.

Before endeavouring to shew what relations numbers such as those which I have obtained hold to the elasticity of a crystal, it would be better that such experiments were repeated by persons who have instruments, good materials, and skilful workmen at their command, which I am sorry to say I have found it impossible to obtain in Japan.

XIX.—*On a probably dimorphous form of Tin; and on some Crystals found associated with it.*

By C. O. Trechmann, Ph. D.

THE behaviour of tin under varying circumstances has frequently attracted the attention of chemists, and several authors have concluded that it is capable of assuming at least two different crystallographic forms, only one of which, however, has been thoroughly investigated. Since Miller* described the beautiful pyramidal crystals of tin obtained by galvanic deposition from a solution of its protochloride, the anomalous appearance of those obtained in the dry way has often been remarked upon. Brooke obtained octagonal needles on slowly cooling molten tin and pouring off the fluid part. Pajot† in a similar manner obtained rhombic prisms. Stolba‡ obtained quadratic plates, whilst Breithaupt§ saw tin crystals, from Cornish smelting furnaces, which had the form of short hexagonal prisms (Miller considered them to be $Cu\ Sn^2$). Lastly Rammelsberg‖ inferred from the varying specific gravity that a not yet determined dimorphic form existed. It is found for instance that electrolytic tin with a sp. gr.=7·18, after being melted and allowed to cool, assumes the higher sp. gr.=7·29, and yet retains a crystalline structure. Whether the crystals of tin to be described below, are the same as those observed by Breithaupt and others, though probable, cannot be decided, nevertheless the observations made on them may assist in solving the question of the dimorphism of this eminently crystallizable metal.

The crystals now to be described were brought to my notice by our able secretary Mr. Collins, who writes as follows respecting them:—"I have received the crystals in question at different periods from the Rev. Canon Rogers, of Gwennap, near Redruth; from Mr. A. T. Davies, of St. Agnes; and, lately, from Mr. A. K. Barnett, manager of the Chyandour Smelting Works at Penzance. They occur in cavities of "hard head," a highly arsenical slaggy

* Phil. Mag., iii Series, 22, 263.—Pogg. Ann. 58. 660—Brooke and Miller: Mineralogy 1852, p. 127—Rammelsb: Handb. d. Kryst. und Chem. p. 14.

† Journ. de Phys. et Chim., t. 38, 52.

‡ Journ. f. pract. Chem. 96, 178. Berz. Jahresb. f. Chem. 1865, 161.

§ Schweigg. Journ., 52, 171.

‖ Ber. d. Deut. Chem. Ges. 3. 724.

material which is produced at a certain stage in the processes of tin-melting. They also occur occasionally in the ordinary slags, also in cavities. They are formed with great rapidity, sometimes in a few minutes.

"In colour they vary from iron-grey to bright steel-grey, the lustre is occasionally almost exactly like that of the "kish" (graphite) formed on pigs of spiegeleisen in cooling. They are flexible but not elastic."

"When heated in a closed tube they give a *very* faint white sublimate but are not otherwise changed; in the open tube they suddenly glow, then deposit a thick white sublimate which is scarcely at all volatile on further heating; on charcoal they glow, deposit a white sublimate of oxide of tin, yielding at the same time faint arsenical and sulphurous odours, and a minute dark, brittle, magnetic bead. With borax bead the following are the results—

	HOT.	COLD.
OF	Brown, then yellowish-green	Pale clear blue
RF	Bluish	Violet-blue

In bead of microcosmic salt—

OF	Green	Very pale violet
RF	Bluish	Violet

"Treated with strong HNO_3 most of the crystals are changed to a white powder, red fumes being given off abundantly; a few minute dark crystals however are scarcely attacked after 10 days digestion in the acid.

"With HCl all the crystals are readily soluble.

"The above reactions shew that the crystals consist essentially of tin, with traces of arsenic, sulphur, iron, and cobalt.

By ordinary humid analysis the results obtained are

	a	*b*
Tin	98·7 p.c.	98·5
Iron ..	1·1 p.c.	1·0
S.As. Fe.Co.	traces	traces
	99·8	99·5
Sp. Gr.	6·5	6·4

"These analytical results shew that the crystals *taken as a whole* are composed of almost pure tin; the minute quantities of the other substances present being insufficient to form an alloy in any ordinary sense."

Their general appearance is that of a loose and irregular mass
very thin plates of different sizes, from about a quarter of an in
square, down to almost microscopical dimensions. The colour a
varies, from a dark iron or graphite grey in the larger specimens, t
light bluish-grey in the smaller ones. Single plates and crystals,
seen under the microscope, appear still lighter, approaching to
bluish-tin colour. The lustre is bright metallic, though frequen
the crystals are covered with a thin dull grey or slightly irides
crust. The crystals are brittle when strained transversely, but aga
pressure they seem to be slightly ductile. A lamination see
apparent in the direction of their greatest length and breadth.

Two determinations of the specific gravity were made with caref
picked and washed crystals, and gave :—

(1) Sp. gr.=6·557 Weight of crystals used 0·1659 gramme.
(2) ,, =6·525 ,, ,, 0·8274 ,,
Temperature, 60·5 F (15·8 C).

Some crystals of electrolytic tin gave, at the same time and un
the same conditions :—

(3) Sp. gr.=7·136 Weight of crystals used 0·3982 gramme.
(7·178, Miller)

On closer examination of the hand specimens it is found that th
are two kinds of crystals intermingled ; the first kind, the thin pla
already mentioned, very greatly predominating in quantity. They
bounded by six sides, of which two are generally wanting, where t
crystal is affixed to its base. Of the enclosed plane angles four a
proximate to 133°, and two to 95°, and the plates represent eith
single individual crystals, or, as is more frequently the case, the edg
at the ends are replaced by a number of smaller crystals, arranged
a parallel position, thus giving the plate a deeply serrated appearanc
as of a double-sided comb, and showing it to be built up of a larg
or smaller number of sub-individuals. Fig. 6, plate IX, is drawn fro
nature, and represents one of these plates.

The crystals of the second kind are very much smaller, of a light
shade of colour, and generally disposed on the surface of, or among
those of the first kind. The single crystals form minute prisms, whic
are also arranged in parallel rows—like the teeth of a comb—and hel
together by a thinner central part, thus forming small plates, of abo
1 mm. square, with protruding points. Fig. 7 shows one of the
composite forms. They are probably some combination of tin wit
other substances, and seem to be of a later formation than the ti
crystals, due probably to a change of temperature or an alteration i

the composition of the surrounding medium. A fuller description will be given below.

Both kinds have often small globules of what appears to be tin attached to their surfaces or in their serrations.

For the sake of distinction it is proposed to call the pyramidal tin, as described by Miller, the α modification or α tin, and the first kind of the above crystals the β modification or β tin.

(1) *β Tin.* As already stated the crystals form very thin plates with prismatic habit, and are frequently built up of a number of sub-crystals. The latter (fig. 2) are exceedingly well formed, rich in facets, with sharp well-defined edges, and though excessively small are well adapted for goniometrical measurement on account of the excellent polish of their surfaces. The planes were free from striations, but the larger ones frequently showed central depressions and lines of growth, such as are seen on artificial crystals of lead sulphide or bismuth, though in a much less marked degree. Five of the best developed crystals, the largest of which did not exceed 1·5 mm. in length, by 0·3 mm. in breadth and 0·1 mm. in thickness, were picked out and measured with very satisfactory results.

System: prismatic, with angles closely approximating to those of α tin.

The following angles, the mean of the best measurements, were used for the calculation of the axial ratio (the angles between the normals are given throughout.):—

$$a : b = 68° 49·5'$$
$$a : d = 75° 19'$$

Axial ratio*:—

$$\breve{a} : \bar{b} : \dot{c}$$
$$0·3874 : 1 : 0·3558$$

(Pyramidal or α tin:—$a : c = 1 : 0·3857$ (Miller)

The observed forms were—

a=010	.. ..	$\infty P \breve{\infty}$
x=100	.. ..	$\infty P \bar{\infty}$
b=110	.. ..	∞P
e=120	.. ..	$\infty P \breve{2}$
d=111	.. ..	P
c=101	.. ..	$P \bar{\infty}$
n=021	.. ..	$2P \breve{\infty}$

*In the description of the elements of a crystal we follow Groth's Zeitschrift f. Krystallographie, and designate the shorter lateral axis a, the longer one b, and the vertical axis c. This of course slightly modifies the symbols of Miller.

They were all well and fully developed, with the exception of *x*, which was exceedingly narrow and imperfect, and *n*, which was only observed on three crystals, and determined by a single approximate measurement (Fig. 2a.)

The following is a table of the angles calculated from the axial ratios, together with some of the measured ones, and some of the corresponding angles of α tin.

Calculated.		Measured, on Crystal No. 4.		Pyramidal or α tin (Miller.)	
$a : a'$	0° 0′		0° 0·5′		
$a : x$	90° 0′				
$a : b$	68° 49·5′	$a' : b$	68° 50·5′	$s : a$	68° 55′
		$a' : b''$	68° 51′		
		$a''' : b$	68° 43′		
		$a : b$	68° 46′		
$a : e$	52° 14′	$a' : e'$	52° 33′		
		$a' : e''$	52° 24·5′		
		$a : e'''$	52° 12′		
		$a : e$	52° 15′		
$a : d$	75° 19′	$a : d$	75° 19·5′		
		$a' : d''$	75° 21′		
		$a' : d'$	75° 21′		
		$a : d'''$	75° 16′		
$a : c$	90° 0′	(Crystal No. 1)	90° 0′		
$a : n$	54° 34′	(,, No. 5)	53° 49′		
$x : b$	21° 10·5′			$s : (001)$	21° 5·5′
$x : e$	37° 46′				
$x : c$	47° 26′	(,, No. 1)	47° 19·5′	$t : (001)$	49° 10′
$x : d$	49° 8′				
$b : b'$	42° 21′			$s : s''$	42° 11′
$b : e$	16° 35·5′				
$b : c$	50° 53·5′				
$b : d$	45° 26′	(,, No. 2)	45° 30·5′		
$e : e'$	75° 32′				
$e : c$	57° 40·5′				
$c : c'$	85° 8′	(,, No. 1)	85° 14′		
$c : d$	14° 41′				
$d : d'$	29° 22′				
$d : d'''$	81° 44·5′				
$d : e$	47° 44·5′				

The close approximation of some of the angles of β tin to those of α tin would seem to suggest that the two are morphologically identical,

but the decided prismatic development and the peculiar physical properties make it extremely probable that we really have to deal with the prismatic system. In order to compare them one with another, the vertical axis of β tin must be multiplied by three, and the short lateral axis a placed in the vertical position, the similarity of the two axial ratios then demonstrates at once their close connection. The forms of β tin expressed as pyramidal ones, for comparison with those observed by Miller on α tin, would then be :—

β Tin.			α Tin.		
a=010	..	∞P∞	m=110	..	∞P
x=001	..	0P	a=100	..	∞P∞
b=011	..	P∞	p=111	..	P
e=021	..	2P∞	r=331	..	3P
d=311	..	3P3	s=101	..	P∞
c=301	..	3P∞	t=301	..	3P∞
n=320	..	$\infty P\frac{3}{2}$			

Of the possible number of planes moreover only one half would be developed, and if we compare the projection of α tin upon its basal plane (Fig. 4,) with that of β tin upon the plane of the macropinacoid (Fig. 5) the absence of pyramidal symmetry becomes very apparent.

The hardness of β tin is somewhat greater than that of α tin. Cleavage very imperfect, parallel to a and also to c. Brittle to mild. Streak iron-grey, shining. The crystals melt easily, burn with a bluish-white flame, and leave a white ash. They are soluble in moderately concentrated HCl. as stated by Mr. Collins above.

The specific gravity given above is probably too low, on account of the admixture of the crystals of the second kind and other mechanical impurities.

(2.) The second kind of crystals referred to above are very sparingly distributed among the plates of β tin ; they seem to be of a complex nature, though containing apparently a large percentage of tin with smaller quantities of iron and other metals, but in what state the components occur cannot be determined until a larger quantity shall have been gathered and submitted to analysis. They are hard and very brittle, with a bright metallic lustre, almost insoluble in concentrated H Cl, and do not melt in the flame, but turn black and lose their form. More correct observations were precluded on account of their minute size and scarcity.

The crystallographic properties of these crystals are, however, not without interest, and may, as soon as their composition is known give rise to interesting comparisons. For the present we can only draw

attention to the fact that there is a close relation between these crystal and those of "iron-olivine" or artificial fayalite.

Despite their almost microscopical dimensions, the largest not exceeding 0·5 mm. in length by 0·15 mm. in thickness, it was possible to measure them with considerable accuracy.

System: prismatic.

Fundamental angles, the mean of the most reliable measurements of three crystals:—

$$m : r = 70° 45·5'$$
$$r : r' = 58° 57'$$

Axial ratio:

$$\breve{a} : \bar{b} : \dot{c}$$
$$0·9018 : 1 : 0·5652$$

Observed forms:—

$a=010$	..	$\infty P\breve{\infty}$
$b=100$	..	$\infty P\dot{\infty}$
$m=110$	..	∞P
$r=011$	..	$P\breve{\infty}$

The following are the principal angles:—

Calculated.	Measured.	No. of Crystal.
$a : a'$ 0° 0′		
$a : b$ 90° 0′	89° 57·5′	1
$a : m$ 47° 57′	$a : m'$ 47° 58·5′	1
	$a' : m'''$ 47° 55·5′	1
$a : r$ 60° 31·5′	60° 31′	2
$b : b'$ 0° 0′		
$b : m$ 42° 3′	42° 7·5′	1
$b : r$ 90° 0′		
$m : m''$ 84° 5·5′	$m' : m''$ 84° 14·5′	1
	$m' : m'''$ 84° 8′	2
	$m'' : m'''$ (83° 58′)	2
$m : r$ 70° 45·5′	$m' : r$ 70° 44′	1
	$m''' : r'$ 70° 47′	3
$r : r'$ 58° 57′	58° 57′	2
	58° 57·5	3

No signs of twinning were observable in these crystals, nor in those of β tin.

In conclusion, I beg to acknowledge my great obligations to Mr. Collins for kindly placing the material for this paper at my disposal, and also for making me acquainted with the constitution of the crystals.

XX.—*Note on Abriachanite.*

By Professor Heddle.

IN my preliminary notice of this substance, I stated, upon the authority of Dr. Aitkin, that it had been supposed that it very possibly had at one time been used as a pigment in Inverness; a colourist there manufacturing a paint the nature of which he kept secret.

In re-arranging lately, a number of chemicals which had been made over to me in 1856 by my predecessor, Mr. Connell, I found a bottle with a powder of the same tint, but somewhat darker than the washed *Abriachanite*. The label of this bottle bore on it "Ultramarine made in 1841, by Murdock Paterson, dyer in Inverness."

I have not yet had an opportunity of analysing this powder, which may be merely abriachanite darkened by simple treatment with an acid.

Dr. Aitken sent me some which had been steeped in hydrochloric acid,—this had however, somewhat too much of the colour of Turnbull's blue.

I have now to announce the discovery of a new locality for the mineral.

An old limestone quarry had been during last spring found by Dr. Aitken, near the road from Inverfarrakaig to Foyers. We examined this together in the autumn. The lime-stone bed is not at all of the same nature as that so amply disclosed on the north side of Lochness, at Glen Urquhart; being fine-granular, close and firm in structure, and grey in colour.

The lime dips at a high angle to the south-east, and is bedded with the gneiss of the district, which occasionally has thin veins of quartzose massive granular *epidote* (epidosite.) Differing in this respect widely from the Urquhart lime, it carries almost no minerals: here and there a vein of pale flesh-coloured, greasy-lustred *orthoclase*, very rarely a striated felspar (*andesine?*) and a little bright, pale green muscovite with traces of epidote.

Cutting the lime, however, and somewhat in the line of its strike there is a tortuous vein of graphic granite, of a delicate pale pink colour. The quartz letterings are usually colourless, but occasionally they are of a red tint.

This granite is rent by "shakes," and in these shakes, and there alone, the *abriachanite* is to be seen *disposed only on the surfaces of the quartz letterings*, and throwing them out in bold character. While this mode of occurrence goes far to prove it to be a product of change, it is itself very singular and difficult of explanation.

The mineral is in a powdery state.

Reviews and Notices.

On the effect produced on Mica, Gypsum, and Calcite, by the penetration of a point. (M. Reusch, *Bull. de la Soc. Min. de la France:* t. 2, p. 6 January, 1879.)—On piercing a lamina of mica or gypsum with rather blunt-pointed needle, regularly arranged cracks are produced having a simple relation to the crystalline axes. In Siberian mic *e.g.* three cracks are produced, one parallel to the plane of symmetr while the traces of the other two are normals to two of the sides the hexagonal. In gypsum, only one crack appears, spreading a lit on each side of the hole formed by the needle: it is parallel, accordi to M. Reusch, to a face $a\frac{9}{5}$ $(\bar{5}09)$ found by M. Hessenberg, in gypsu from Wosenweiter.

If a lamina of rock-salt, gypsum, or mica be placed on a gla plate as support, with or without a layer of indiarubber, and a caref blow made with a small, very blunt-pointed punch, cracks ar produced, which are analogous to those made by the needle, but the have not always the same directions. With rock-salt, the cracks ar parallel to the faces of the rhombic dodecahedron.

When a lamina of calcite is placed on an india rubber support, an a wooden punch, terminated by a sort of spatula with rounded edges is so placed on the plate that the plane of the spatula about follows plane b^1, and a slight pressure employed, a very regular fissure i produced, parallal to $\bar{b}^1$, and crossing the whole flake without breaking it.

Similar fissures are produced with sodic nitrate. Gypsum, in flake whose cleavage is parallel to the plane of symmetry, splits under th blow of a punch according to a plane $a\frac{9}{5}$ (509,) exactly perpendicular to that plane.

Some additional remarks on the figures produced in gypsum are made by M. E. Jannettaz, whose mode of proceedure avoids any blow His results have been long published in various journals.

R. C. B.

On the Theory of Hemitropism, and especially that of Disthene and Grey Copper. (M. Mallard, *Ibid.* p. 9.)—It has been observed by vom Rath (in the Zeitschrift of M. Groth,) that besides the two crystalline axes which have been taken by him for the axes of the Z's and Y's,

and which form a right angle, there is also another crystalline reticulation (rangée du reseau crystallin,) which is nearly perpendicular to the other two, and normal to the face h^1 (100); that these three crystalline axes are not axes of symmetry: and that disthene is accordingly not rhombic, but that its crystals may be studied as tetartohedrons of the rhombic system.

The author remarks that the crystallography of disthene is of great interest. If we consider the plane parallel to the twin-plane, and which contains molecules whose centres of gravity occupy the intersections of a reticulation whose meshes are parallelograms, these intersections return to the same positions when a semi-revolution is made round an axis normal to the plane and passing through an intersection. The centres of gravity of the molecules which occupy the two reticular planes situate opposite to and respectively belonging to the two parts of the twin crystal, thus hold the same relative position as in the rest of the crystal. From this explanation it appears that the macle requires a twin-plane which is a reticulation with very small meshes, *i.e.*, a plane belonging to one of the simplest forms of the crystal; and a twin axis normal to this plane. The author has shown *(Annales des Mines)* that one of the best known exceptions; the macle of orthose by hemitropism round the vertical edge g^1 h^1 (001,) not perpendicular to a simple form (law of Carlsbad,) and in which the twin-plane is not normal to the twin-axis; is due to the reticulation plane g^1 (011) of orthose evidently having a rectangular or lozenge-shaped mesh: one of the diagonals of the lozenge, or one of the sides of the rectangle having the direction g^1 h^1, brings the intersections of the reticulation almost to the same points of space, Therefore there can be—from the theory of Bravais—a twinning of the orthose round g^1 h^1, and a union of the two parts parallel to the face g^1, which is the definition of hemitropism according to the law of Carlsbad. Moreover if the arrangement of the reticulation of orthose explains the possibility of hemitropism round the vertical edge, it explains also its existence, for the mesh of the plane of symmetry g^1 being a rectangle, the two sides of the rectangle are axes of binary pseudo-symmetry.

The same considerations should apply to disthene, since its reticulation exhibits, like orthose, three evidently rectangular directions. Twin axes can and should obtain in these three directions;—(1) a straight line normal to the face h^1 (100:), (2) a straight line parallel to the intersection of the faces g^1 (010) and h^1 (100:), (3) a straight line parallel to the intersection of the faces p (001) and h^1 (100). In each of these three cases the twin-plane will be parallel to h^1. The

first case is strict hemitropism, but the other two are hemitropes not exactly normal to crystalline faces, with twin-planes parallel, not normal, to the twin axis. These three macles have been long known in disthene, and are among the principal characteristics of that substance. Moreover it must be added that vom Rath has observed a new macle of disthene, rarer than the foregoing, about a normal to the face p, and lastly a fifth and much rarer hemitropism, about an axis normal to a face $a\frac{3}{2}$ ($\bar{3}08$.

The preceding observations, and those which the author has made previously on the hemitropism of orthose, modify and complete in one important point, the theory of twin phenomena. It is usually said that twinning takes place about an axis normal to a face, which is then the plane of re-union. But twinning can also take place about a parallel to a crystalline axis, if that axis be an axis of binary symmetry of the reticulation of a certain face; it is then a plane of re-union, *parallel* to the twin axis.

For the production of this particular hemitropism, it is enough that the twin axis be an axis of symmetry, or of quasi-symmetry. When the axis is at the same time an axis of symmetry, there is always a more or less intimate penetration of the macled crystals. In the general case, on the contrary, and when the axis of hemitropism is only a quasi-symmetrical axis of the reticulation, there is no physical reason which will permit the two reticulations to interpenetrate, and the plane of reunion is very clearly marked.

A curious example occurs in the macles of grey copper, studied by M. Sadebek. Hemitropism takes place according to two different laws: (1) the twin axis is an octahedral axis (ternary axis;) the plane of union is either a plane a^1 perpendicular to the axis, which seldom occurs, or else a plane a^2 (211) parallel to the axis, which is the general case: (2) one of the crystals has twinned through 90° about the vertical axis; the two crystals penetrate each other, and there is no plane of union. The second law has been thoroughly worked out by Bravais under the title of molecular hemitropism. The first law is easily explained. The ternary axis may be an axis of hemitropism in the ordinary sense, since it is perpendicular to one of the faces of the octahedron, *i.e.* to one of the simplest crystalline planes. This is really what obtains in most holohedral crystals of the regular system. The spinels are almost all thus macled. But one face a^2 (211) is parallel to a diagonal of the cube, and to a diagonal of the faces of a ternary axis and a binary axis: these two lines being perpendicular, the reticulation of the plane a^2 is a rectangle, one side being a ternary

xis, which is thus an axis of symmetry. Thus hemitropism can occur bout the ternary axis, with the face a^2 as the plane of reunion.

But it may still be asked why, whilst holohedral crystals, as spinel, ke as their twin-plane the face of the octahedron, hemihedral crystals, ch as grey copper, (*Fahlerz*) take for twin-plane the face a^2, preserv- g the same twin-axis. To find the reason of this difference, it must noticed that in holohedral crystals there is symmetry in the ystalline structures on each side of the twin-plane. If P is a face longing to the portion of the crystal which is supposed to be fixed, d P' a parallel to it; after the hemitropism, P' comes to a position mmetrical with P as regards the plane normal to the twin-axis. In ese tetrahedral crystals, the face P has no longer its parallel, and if mitropism takes place with a twin-plane normal to the twin-axis, e two portions of the crystal would no longer be symmetrical with spect to this plane. If on the contrary hemitropism takes place th a twin-plane a^2, it is obvious that the two portions are symmetri- l as regards this plan. In fact the twin-axis is contained in a plane symmetry which is common, after rotation, to the two parts of the ystal. Therefore the two portions will, after rotation, be symmetri- l, with respect to a plane passing through the axis and normal to e plane of common symmetry. But this plane passing through a rnary and a binary axis, is a plane a^2.

It is evident then that if, of the two possible methods of hemitropism out the tenary axis, the tetrahedral crystals solely adopt that one ose twin-plane is a^2, it is because it is the only one which makes e twin-plane a plane of symmetry.

R. C. B.

Note on the Titaniferous Peridot of Zermatt. (M. A. Damour, *Ibid*, 15.)—Occurs embedded in veins of calc-spar traversing the large ocks of talcose schist scattered over the southern moraine of the acier of Findelen, near Zermatt in Valais. As in the titaniferous agnesian silicate from Pfunders in Tyrol, this peridot is of a reddish our, like Almandine Garnet, for which it might be mistaken. wder orange-coloured. Transparent in thin slices, and shows a cided dichroism under the polarising microscope. Its form is rived from the right rhomboidal prism. Hardness between felspar d quartz. Density=3·27. On the application of heat a very small antity of water is disengaged, without change of colour. Infusible B., but blackens, and loses its transparency. Powdered and treated th hydrochloric acid, is decomposed: a yellowish powder (titanic id) remains. On evaporation, the liquid forms a jelly. Analysis as

follows, at (*a*,) to which is added the analysis of the similar mine from Pfunders (*b*)

	b	Oxygen.		*a*
Silica	36·14	19·27 } 21·68		36·30
Titanic acid	6·10	2·41 }		5·30
Magnesia	48·31	19·09 }		49·65
Oxide of iron	6·89	1·53 } 20·67		6·00
Ditto manganese	0·19	0·05 }		0·60
Water & volatile matter	2·23			1·75
	99·86			99·60

The oxygen ratio approaches therefore 1 : 1, which is that foun peridot-olivine.

From its physical characters and constituent elements, this mi seems to deserve a distinct place among the peridots, and the n Titan-olivine is proposed.

R. C. B.

Mechanical separation of the various Minerals of Rocks. (M. J. Thou *Ibid*, p. 17.) The author makes use of Sonstadt's solution of merc iodide in potassic iodide, the density of the liquid being reduced as n be desired by the addition of water. Illustrations of his apparatus given, and a description of the method of using it. (Compare *Ch Min. Mag.* Vol. 1, p. 23.)

R. C. B.

Anatase, from Diamantino (Brazil). (M. E. Bertrand. *Ibid.* No Feb., p. 30)—These crystals exhibit only the octahedral face (114): on fracture they were found to be almost entirely conver into needles of rutile: there were two very clear and brilli cleavages, making an angle of 136°36′, a characteristic of the cleava b^1 (112) of Anatase. This confirms Damour's observation, that crystals known as "Captivo di cobre," are pseudomorphs of anat in rutile. Specimens crystallographically identical, *i.e.* having o the faces b^2, come from Binnen in Valais, these are usually ca Wisérine.

R. C. B.

Pyroelectricity of Topaz, Blende, and Quartz. (C. Friedel. *Ibid.*,p. —The author makes his observations on a crystal whilst it is be warmed by a heated hemisphere of metal, which is placed over it, stead of on a previously warmed crystal during its cooling. W topaz he finds that a pyro-electrical axis exists perpendicular to cleavage, and therefore coinciding with the axis of hemimorph

shown by the hemihedral faces. His observations appear to be at variance with those of Ries and Rose, according to whom there exists a series of central analogous poles along the axis of the crystal, and two series of analogous poles on the obtuse edges of the prism, but possibly their experiments were made on imperfectly homogeneous crystals, a condition often exhibited by topaz. Blende from Europa Point, in large slices cut perpendicular to a diagonal of the primitive cube, gives electrical tensions of contrary sign with the two opposite faces: the diagonals of the cube are therefore pyroelectrical axes. M. Hankel found that during the cooling of right-handed quartz, a negative tension was exhibited on the middle and left side of the faces p (the upper part of the crystal being considered), and on the right side a feebly positive or negative tension, or none at all. The faces $e\frac{1}{2}$ exhibit an analogous electricity, positive being replaced with negative. The prismatic faces are divided into two portions of opposite electricities by a diagonal going from the right-hand above to the left-hand below; the part adjacent to the faces p is negative: that adjacent to $e\frac{1}{2}$ is positive.

The author finds that the alternate edges of simple crystals are of opposite sign, and are the same in their whole extent. The edges of the rhombohedral faces always gave a positive tension on contact with a warmed proof plane; the opposite edges gave a negative tension. The horizontal axes of the trigonohedron, *i.e.* the diagonals of the base of the hexagonal prism of quartz, are therefore axes of pyroelectricity. The two extremities of the principal axes of the crystal present no electrical difference.

On Chromite.—(M. J. Thoulet. *Ibid.* p. 34.)—This mineral is transparent when cut into thin slices, like the ordinary rock-sections for the microscope. With transmitted light its tint is yellow, blended with red; it often shows more or less perfect sections of octahedra, and many straight or curved fractures filled with the surrounding rock, sometimes serpentinous, as in the chromite from Röros in Norway, sometimes calcareous, as in that from Negropont. The sides of the crystals lining these fissures are frequently impregnated to a certain depth with oxide of iron, giving rise to a dark, sometimes black color. Under reflected light, it has a violet-rose or greyish colour, while the spots impregnated with iron have their characteristic blue metallic reflection. This mineral is very slowly attacked by hydrochloric acid when powdered. From the result of actual experiments, it seems that it is irregularly attacked, owing to the separation of some elements in preference to others. Chromate of iron from Negropont, purified as

much as possible from foreign matter, after a digestion for three weeks in hot hydrochloric acid, gave the following composition on analysis—

Sesquioxide of chromium	67·0
Magnesia	·4
Alumina	16·8
Protoxide of iron	19·9
	104·1

Chromite belongs to the group of spinels, where the relation between the oxygen of the base and that of the acid is 1:3; but in this case, the relation is 1:6·3, and it is evident that the mineral has been attacked by the acid. Another specimen from Baltimore gave 38 to 40 per cent. of sesquioxide of chromium. M. Fischer, of Fribourg, has already observed this admixture of oxide of iron. In the specimen studied by the author, the particles, notwithstanding their long digestion, when they were quite transparent under the microscope still adhered to the magnet in an evident though feeble manner.

The index of refraction was obtained by placing the previously polished slice vertically in the centre of a very correct Babinet's goniometer, furnished with an apparatus capable of making a series of horizontal, vertical, and rotary motions. On the plate was directed a pencil of monochromatic light, polarised perpendicular to the plane of incidence, having traversed a Nicol with the smaller diagonal horizontal. The pencil, after reflection, is received in a microscope provided with a Nicol analyser. Examined in this manner, some substances give a total extinction, or nearly so (*e.g.*, specular iron, chromite, titanic iron, oxide of iron, &c.); others never extinguish, but reduce the brilliancy (pyrites, mispickel, galena, &c.) The former exhibit, after reflection, rectilinear, the latter an elliptical polarisation. The angles of incidence which produce either a complete extinction or a diminution of brightness vary sufficiently in the above minerals to constitute specific characters for the recognition of each. Now in transparent substances the tangent of the angle of incidence at which extinction takes place is equal to the index of refraction. The chromite gave an extinction at an angle of 64° 30′: hence its index = 2·0965.

R. C. B.

On the resistance to change offered by the faces of Crystals in their Mother-Liquor.—(M. LECOQ DE BOISBAUDRAN. *Ibid.* p. 37.)—The author finds from many experiments,

(1.) That different isomorphous crystals are not equally acted upon by a solution of one of them.

(2.) An extremely small variation in the concentration of the solution does not cause a sudden transition from a state of very slow solution of crystalline surface, to that of a very slow deposition, but that each face remains intact, without loss or gain, in a mother-liquor whose density varies within certain limits, of small extent it is true, but still easily observable.

(3.) This resistance to change varies for each system of faces, so that a change in the external conditions (such as an alteration in the composition of the liquid, in the temperature, &c.) very often changes the relative resistances of two given systems of faces.

(4.) A mobile equilibrium does not exist between a crystalline face and its mother-liquor; a continual change of molecules does not obtain, but there is either a continuous erosion or deposition, or else—between the limits of resistance—neither.

Great precautions were taken, the experiments being conducted in a deep vault under a rock, closed with double doors.

R. C. B.

Hemihedral Forms of Alums.—(By the same. *Ibid.* p. 41.)—The author obtained an octahedron of alum with four smooth faces and four rugose, representing the union of two inverted tetrahedra. It had been obtained by immersing for some hours an octahedron of potash-chrome-alum in a slightly supersaturated solution of basic alumino-ammonium alum, giving cubes on crystallisation.

R. C. B.

Retinite, from Russia.—(M. F. Pisani. *Ibid.* p. 42.)—Under the name of manganese garnet, the author had a large specimen of somewhat testaceous structure, and in some measure polished: its colour was like that of a garnet, but its density was less, and it swelled up greatly before the blowpipe, becoming white before melting.

Density = 2·31. On analysis it gave:—

Silica	67·50
Alumina	16·34
Ferric oxide	1·16
Lime	2·20
Soda	3·92
Potash	3·88
Loss on ignition	5·90
	100·90

The somewhat testaceous structure of this specimen connects it with perlite, but its composition is rather that of a retinite.

R. C. B.

Wagnerite from Bamle. (By the same. *Ibid.* p. 43.) The name Kjérulfine has been given to a fluo-phosphate of magnesia, containing much lime, from Bamle, in Norway. Under the name of "crystallised Kjérulfine" the author had received large crystals, up to many kilograms in weight, in rhomboidal prisms of 122°. The interior was sometimes in great part homogeneous, composed of a yellow vitreous substance, which is almost pure Wagnerite, and sometimes traversed by whitish veins, containing much lime (mixture of apatite), sometimes almost entirely formed of a whitish or rosy matter, which is principally apatite. Some crystals, yellow inside, are enclosed in a white stony crust of apatite. Hence it appears that the crystals of Wagnerite from Bamle are frequently pseudomorphs. Density = 3·12.

The analysis of this Wagnerite gave:—

Magnesia	34·7
Lime	3·1
Phosphoric acid	43·7
Magnesium	6·8
Fluorine	10·7
Residue	0·9
	99·9

These numbers agree with the usual formula of Wagnerite, and prove that Kjérulfine is not a particular species, but a Wagnerite. Moreover the prism of these crystals is the same as the derived prism $g^3 = (210)$ prevailing in the Wagnerite from Werfen in Saltzburg, where this mineral was first found.

R. C. B.

Occurrence of Gold in certain Minerals of the United States.—(M. M. CHAPER. *Ibid.* p. 44.) A discussion on the occurrence of gold in copper and iron-pyrites, and as telluride.

R. C. B.

Crystalline form of Ferromanganese.—(M. E. MALLARD. *Ibid.* p. 47.) The advantage in using spiegeleisen in the Bessemer process having been attributed to the manganese, it was sought to increase the proportion of this metal. Under the name of ferromanganese certain crystalline products are prepared, containing from 11 to 85 per cent. of manganese.

From the examination of two excellent sets of specimens in the École des Mines, the author finds that with a proportion of from 11 to 52 or 55 per cent. of manganese, the substance retains the same crystalline form, that of a prism of 112° 33′, modified by tangent

faces on the acute angles of the prism. If the prism be designated by m (110), the modifying faces will be indicated by g^1 (100), and these last are usually very much developed. Between 52 and 55 per cent. of manganese, the crystalline form undergoes a sudden change. The structure, till now decidedly lamellar, becomes rod-like and cylindrical; the small parallel rods are hexagonal prisms with faces forming angles of about 120°, without clear terminations. They are very difficult to measure, the faces being slightly rounded do not always give clear images. The results of two measures made on relatively very good specimens are as follows:—

I.	II.	MEAN.
61° 14′	61° 20′	61° 17′
60 29	59 50(?)	60 9
59 20	60 01	59 40
59 00	59 7	59 4
61 12	60 47	61
58 42	58 57	58 50

However, these measures show that the form is that of a rhombic prism of 120°, modified by the tangent faces g^1.

It is a curious point that with a continually varying chemical composition the crystalline form should change suddenly. Troost and Hautefeuille have shown that iron, manganese, and carbon form real definable chemical combinations in ferromanganese. This fact is also proved by the complete disappearance of magnetism, which takes place with proportions of manganese varying between 20 and 34 per cent. In trying to explain the permanence of the crystalline form with a variable composition, it might at first be thought that the crystals have a composition different from that of the mass whence they separate. But careful analyses made in the laboratory of the École des Mines have shown that the crystals have exactly the same composition as the mass. It must be admitted, then, that these crystals are formed by definite compounds, which unite in variable proportions, and take the crystalline form of the predominating compound.

R. C. B.

Brushes of Polychroic Crystals.—(M. A. Bertin. *Ibid.*, March, p. 53.) A physico-mathematical essay on the theory of the "brushes" given by biaxal crystals. The substances whose optical deportment is studied are andalusite, cordierite, epidote, mica, axinite, topaz, diopside, acetate of copper, clinochlore, platino-cyanide of yttrium, and "Sel de Senarmont," this last being the salt which de Senarmont prepared in 1854, by colouring nitrate of strontia with logwood.

"Brushes" exhibited by Uniaxal Crystals.—(M. E. Bertrand. *Ibid.* 57.)—The author remarks that up to the present time brushes not o had not been observed in uniaxal crystals, but even their very existe seemed improbable. But they do exist, and in a very plain manr The platinocyanide of magnesium crystallises in square prisms, a cleaves perpendicular to the optic axis. If a cleavage slice, as thin possible, be held very close to the eye, a reddish-violet disk on a v million ground is observed, with ordinary light. With polarised lig two red brushes on a carmine ground appear, the middle line of t two brushes being perpendicular to the plane of polarisation. T is to be explained by the fact that this substance is very strong dichroic, and a thin plate parallel to the axis absorbs all colours cept red, while a slice perpendicular to the axis allows blue and vi rays in addition to pass. In fact, a somewhat thick slice, per dicular to the axis, examined with the spectroscope, shows only extreme red end of the spectrum, but on its thickness being redu the violet end appears, and absorption of the intermediate part a obtains. Consequently if a thin plate of the platinocyanide, perp dicular to the axis, be examined with ordinary light, the rays wh arrive at the eye parallel to the axis, or nearly so, will appear viol but as the rays depart more and more from the normal to the plate, blue and violet rays will be more and more absorbed, since they dep from the direction of the axis, and also because they traverse a grea thickness. Thus a violet disk on a red ground is seen.

The absorption of the blue and violet rays increases very rapi in this magnesium salt, with the thickness of the plate and its obliqu to the optic axis; so that with a very small angle these rays are co pletely absorbed, and a very small disk is seen on a red ground. tourmaline, a negative crystal, the phenomena are not so apparen for a much greater obliquity in the ray is required to render the a sorption manifest. It also absorbs rays parallel to the axis more th those perpendicular to it, so that it is opaque parallel to the axis, a becomes more transparent as the ray diverges: but as the obliquity the ray increases, it traverses a greater thickness, so that the absor tive power of the tourmaline is increased.

The phenomenon is visible, with both ordinary and polarised ligh in tourmaline, the coloured uniaxal micas, especially in pennine, a generally in all uniaxal dichroic crystals: but to observe it in the crystals, the plate must be inclined successively in different direction so as to have a sufficient obliquity.

The appearance of brushes with polarised light in the case of th platinocyanide of magnesium is due to the blue rays reaching the e

in a direction oblique to the axis not being absorbed when these rays are in the plane of polarisation, or nearly so; but when perpendicular, or nearly so, to the plane of polarisation, they are completely absorbed. Two red brushes on a violet ground then appear, their middle line being perpendicular to the plane of polarisation.

A similar phenomenon is observed with ordinary light, when a Nicol or a tourmaline is held between the eye and the crystal. If the crystalline plate be placed between two Nicols or parallel tourmalines, the brushes remain the same, but the rings are divided into four parts. If the two Nicols are at right angles, or if the polarising microscope, or the tourmaline forceps, be employed, and the two planes of polarisation are at right angles, the black cross and rings appear on a uniformly red ground, for those blue rays which are not absorbed by the first piece of apparatus, are cut off by the second. On the analyser being turned through a right angle, the field is divided into four sectors, alternately red and violet. Pennine, Biotite, alurgite, &c., examined with the polarising microscope in converging light act similarly, when the analyser is turned.

R. C. B.

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On Crystallized Chromate of Baryta.—M. L. Bourgeois (*Ibid.* p. 83.)—A mixture of two equivalents of baric chloride, one equivalent of potassic chromate, and one equivalent of sodic chromate, was melted at a bright red heat, and then allowed to cool slowly, when the interior was found to contain some bright prismatic crystals. They were released from their gangue by extracting with boiling water, which dissolved the chlorides. Spec. Grav. = 4·6: colour varies from fine green to sulphur-yellow. Easily dissolve in hydrochloric or nitric acid, giving an orange solution. Concentrated sulphuric acid decomposes the crystals, with formation of baric sulphate and chromic acid. Attacked by potash with difficulty, forming an alkaline chromate and baryta. The crystals contain 60·4 p.c. of baryta, and 39·6 of chromic acid: formula therefore = $BaCrO_4$. They belong to the type of the right prism with rhombic base. Angle of this prism $m = (110)$ is 102° 11′. At the extremities of the prism and on the obtuse angles a, very small faces sometimes occur, containing an angle of about 103° 30′: on the acute angles e there are also small obscure faces, whose angle is about 114°. In baric sulphate, $m\ m = (110)\ (1\bar{1}0) = 101°42'$: $a^2\ a^2$ on $h^1 = (102)\ (10\bar{2}) = 102°18'$: $e^2\ e^2$ on $g^1 = (201)\ (20\bar{1}) = 113°26'$. So that the chromate and the sulphate of baryta are isomorphous.

R. C. B.

EPISTILBITE.—(C. A. TENNE.—*Neues Jahrb. für. Min.* 840, 1879.)—The author in a short communication to Prof. C. Klein, states the results of his examination of the specimens of Epistilbite in the collection of the University of Göttingen.

The mineral is oblique, and the crystals hitherto regarded as single are really twins on (100,) which are partly contact and partly penetration twins. The plane of the optic axis lies in the clinopinacoid. The first mean line is inclined to the principal cleavage at an angle from 81° to 81° 30′.

T. D.

A NEW MICROSCOPE FOR PETROLOGY.—At our last meeting a new Microscope was exhibited, which has been specially designed for this study at the request of Mr. Rutley, of H. M. Geological survey, by Mr. Watson, of Pall Mall, who was kind enough to attend and explain its construction. By its arrangements the angles of the most minute crystals may be measured with facility and accuracy. The stage centres by means of two screws so as to revolve truly about the optical axis of any objective, and the arrangement of the polarizing apparatus is such that it may be thrown in and out of the field of view instantly, and the phenomena of plane and circularly polarized light applied to the object under investigation. There is also an arrangement for use as a stauroscope shewing the rings and interference crosses with convergent polarized light. It is furnished with graduations shewing the amount of rotation of the prisms, and also with a wedge of quartz and graduations for measuring depth or thickness as suggested by Mr. Sorby.

These arrangements are made on a plan calculated not to impair the instrument for any of the ordinary purposes of microscopy, and are so far very satisfactory.

I may mention that the diagrams accompanying Dr. Trechmann's paper, which were so highly complimented at the meeting, were (I believe) made with one of these instruments.

J. H. C.

FINNISH MINERALS.—(F. J. Wiik, *Groth. Zeits, für Kryst. und Min. Band II, Heft.* 4 *and* 5)—*Euralite.*—By this name has been distinguished a mineral of secondary formation from the Eura-Kirchspiele in the S.W. district of Finnland. It forms a dark-green apparently dense mass, which in three different sections appear distinctly crystalline under the microscope; with a radiated lamellar texture similar to pyrophyllite. H = 2.5, G = 2·62 : B.B melts readily; disolves perfectly in HCl. An analysis

gives the following composition, from which it will be seen the mineral approaches Delessite.

	OBSERVED.	CALCULATED.
SiO_2	33·68	33·45
Al_2O_3	12·15	12·26
Fe_2O_3	6·80	6·37
FeO	15·66	16·59
MgO	17·92	18·43
CaO	1·34	1·43
H_2O	11·49	11·47
	99·04	100·00

It may be expressed by the following formula.

$R_9 R_4 Si_4 O_{29} + 8$ aq. in which $R = \frac{18}{28}$ Mg. $\frac{9}{28}$ Fe and $\frac{1}{28}$ Ca : R $\frac{3}{4}$ Al and $\frac{1}{4}$ Fe. Euralite is found in a Diabase, containing olivine, similar to the olivine diabase of Delarne in Sweden. The olivine is distinctly crystalline and contains nearly as much oxyde of iron as that of Asbyn in Sweden, according to Strüve 36·36 p.c. : the Felspar, parallelopipedon in form contains about 13 p.c. CaO : has a sp. gr. = 2·71 and is Labradorite. The Augite which exhibits a dark violet color in section has a sp. gr 3·24 and the following composition SiO_2 50·18, FeO 18·35, MgO 11·31, Ca O 19·49 = 99·33 giving the formula 3 $CaSiO_3$, 3 $MgSiO_3$, 2$FeSiO_3$.

Sillimanite (Fibrolite).—In the pegmatite granite of St. Michael, small colorless needle-like crystals are observed without terminations, strongly marked by the repeated combination of the prisms in oscillatory combinations. In polarised light these needles show that they belong to the rhombohedral system ; they have a distinct fracture. Their composition like that of the Xenolite of Peterhof ($Al_2Si_3O_{12}$) gives the following analysis SiO_2 47·33, Al_2O_3 (with a trace of Fe_2O_3) 52·21 = 99·54. At Henriksnäs near Knopis a fibrolitie mineral is also found.

Titanite and *Orthite.*—At Eresby in Pargas-Kirchspiele brown titanite crystals are found in limestone of a rhombohedral-like form. The combination ∞ P, O P (110·001) gives

	OBSERVED.	CALCULATED (*Descl.*)
110 : 1$\bar{1}$0	66° 25′	66° 29′
110 : 001	65° 30′	65° 35′

In other limestone deposits of S Finnland (Kyrkslälz Mäntzäla, Karis) occurs a darker titanite of an entirely different form—namely, tabular-like, from the preponderance of an ortho-pinakoid (100) of which the following forms occur, (110), (111), (11$\bar{1}$), (112), (11$\bar{2}$), (001), (010) : hence is assumed the fundamental form of Descloizeaux.

The crystals are often twins according to (100). The following angles have been measured.

	OBSERVED.	CALCULATED.
100 : 110	= 33°	33°15′
100 : 111	= 35	35·5
111 : 1$\bar{1}$1	= 43·20	43·48
111 : 110	= 27·18	27·14
110 : 11$\bar{1}$	= 44·—	44·7
111 : 112	= 12·20	12·35

The difference in these two forms, appears to depend on the fact that the one is found in the limestone, whilst the other is surrounded by scapolite. Titanite in fact conducts itself here in a similar way to pyrites, magnetite, garnet, &c., which as isolated crystals in metamorphic schists show themselves in the simplest form, but wherever they occur in mass or in crystalline (eruptive) rocks, take for the most part the more complicated ones. This relation proves clearly the influence of external media upon secondary crystalline forms indicated by Blum, which deserves from both a geological and crystallographic point of view every consideration.

As a further proof of this influence may be cited in addition that in the limestone of Pargas the scapolite crystals have taken principally the deutero-prismatic form whilst in those of the island of Laurin Kari the proto-prismatic form predominates. In the last scapolite referred to we discover small orthitic crystals of a similar tabular form to those of the titanite crystals mentioned above. In a crystalline fragment with the forms (100:210:011, 10$\bar{1}$. 110) the following angular measurements have been made.

	OBSERVED.	CALCULATED. (*Koksch.*)
110 : $\bar{1}$10	= 70°45′	70°48′
100 : 210	= 35·20	35·8
210 : 10$\bar{1}$	= 47·6	47·50

Phlogopite.—In the greater number of the lime-deposits of S. Finnland those varieties of mica are found which occupy a position between Biotite and muscovite. Those examined have an angle for the optical axis varying from 10° to 30°, the angle lying in the brachy-diagonal section. They are not as a rule distinctly crystallised; in the Pargas variety alone is there any approximation to a distinct crystalline form, and a considerable crystal from this situation shows a combination of surfaces according to Tschermak's indication: ($\bar{1}$11) (112)—(132)—(023) (021) (001. The crystal is prolonged to a pyramidal surface and exhibits the same monoclinic aspect as the Biotite of Vesuvius, a twin striation similar to that of aragonite passes through the crystal in the direction of a surface (130).

Plagioclase and *Orthoclase*.—Descloizeaux's optical distinction as well as the distinction pointed out by vom Rath in the application of the Pencline law have been applied in the determining the place of these in the series instead of depending as formerly on the sp. gr. The deviations of the anomalous twinning-axes as well as the optical *angle of divergence* at (010) from the angle (001 : 010) are given in degrees, from which it is to be noted that those at the obtuse angles in the direction between the corners 001:010 and 010:110 are marked with −v, those at the acute angle with + v.

	Sp. Gr.	Direction of Anom. Twin-line at 010.	Direction of Opt. Ang. of Diver. at 010.
Albite, Somero	2·622	20° (−v)	20° (−v)
Oligoclase (green), Silbole	2·643	9−7 (−v)	15−10 (−v)
Oligoclase (white), Kimito	2·664	5−4 (−v)	0
Andesine (red), Slausvik	2·670	0	10 (+v)
Labradorite (green), Logo	2·699	1−2 (+v)	15 (+v)
Anorthite (Lepolite), Logo	2·7−2·8	14−15 (+v)	35−40 (+v)

Therefore the sectional directions of the anomalous twin surfaces (the rhombic section of Rath) and those of the plane of the optical axis uniformly change; so that the plagioclases form in this respect a series which would not be opposed to the theory of Tschermak

Amphibole and *Pyroxene*.—Analyses of these are here given as well as that of a Hypersthenic looking mineral.

	1	2	3
SiO_2	51·88	52·80	51·47
CaO	23·88	19·08	17·51
MgO	17·09	18·31	11·98
FeO	4·32	5·52	15·06
MnO	0·89	——	——
Al_2O_3	1·19	6·10	3·91
	99·25	101·81	99·93

	4	5	6	7
SiO_2	51·74	52·05	49·1	48·64
CaO	1·79	1·35	3·9	3·23
MgO	16·45	17·24	9·4	16·54
FeO	20·35	20·72	28·6	27·42
MnO	0·41	0·26	——	——
Al_2O_3	8·55	9·46	7·3	4·33
	99·29	101·08	98·5	100·16

1 Malacolite, colorless or lightly colored in the limestone of Wampula. —(Suchsdorff).

2 Malacolite, green, from Javastly, sp. gr. = 3·045.—(Rengvist).

3 Augite, green crystal in orthoclase, from Helsingfors.—(Serenius)

4 and 5 Anthophyllite (rhombic) dark brown with a bluish flash color, sp. gr. 3·022 – 3·045 (4 by Resenius, 5 by R. Stadius).

6 Hornblende, Anthophyllite-like (Monoclinic) fracture in the dir tion of the prism, cleavage in the orthopinakoid direction. Greenish bl without change of color.

7 Hypersthene (?) dark green texture, radiating (F. J. Wiik).

The last named minerals from their distinct cleavages, though ve similar to each other, can be clearly made out by optical means, the rhom anthophyllite conducts itself in polarised light similar to bronzite ; hornblende (No. 6) to diallage, from which it distinguishes itself by cleavage according to the hornblendic prism.

Similar anthophyllite-like amphiboles occur in small fragments in Gabbro-like rock of Kurei. They are impregnated by small needle- microlithes, brown in color and lying in the direction of the vertical of the mother mineral, sometimes they are light green and are t usually normal or placed obliquely to that direction. The amount of i exercises an effect upon the crystallographic direction of the minerals. may be remarked that the anthophyllites from Stansvik and Kurei a accompanied by an apparently pyrargyrite-like mineral derived fr cordierite, epidote. A crystal from Heponselkä exhibited the follow surfaces, (001), (100), (i01), (101), ($\bar{2}$01), ($\bar{2}$11), (110), (210), (320), ($\bar{2}$2 ($\bar{1}$11), (011), ($\bar{3}$11), ($\bar{4}$12). T. A.

THE FORMULAS OF LEPIDOLITE.—In the article by Rammelsberg (*Mona ber. d. Berlin, Akad*, 1878) on the composition of Lepidolite it is stated a the conclusion : "Tschermak has lately employed the analyses made b Berwerth to deduce from them the composition of Lepidolite. As thes analyses, with the exception of those of Zinnwald, in relation to th Lithia are incorrect, so also must the formulas founded upon them b Tschermak be so." With reference to this observation Prof. Tscherma makes the following remarks :—

Those who have read my treatise "On the chemical composition o Mica" will have remarked that in it the composition of Lepidolite i not deduced exclusively from Berwerth's analyses, but that I used al recent analyses of potash micas containing Lithia to discover the chemica combinations which occur chiefly in potash micas, whether they aboun in or are poor in Lithia. If therefore in one of the analyses used by m a single quantity may not be perfectly correct, it does not follow from thi that the assumed formula is so.

As to the disputed estimation of the Lithia in the analyses of the Lepidolite of Paris and Rozena, a certain and unprejudiced judgment will be impossible, until Herr Berwerth has made new analyses.

The objection on the contrary which Rammelsberg raises against the formula supported by me may now be tested, as it rests upon the calculations assumed by him. I cite therefore the values reckoned and found by Rammelsberg, as well as those by myself, and the calculations of Berwerth, all in relation to the lepidolite of Paris.

	Rammelsberg.		T.	Berwerth.	T.
	Calc.	*Found.*	*Calc.*	*Found.*	*Calc.*
Fluorine ..	5·64	5·60	5·53	5·15	5·17
Silicic Acid	50·76	..	50·90	50·39	50·77
Alumina ..	28·93	28·43	28·09	28·19	28·01
Potash ..	11·93	10·89	11·65	12·34	12·78
Soda ..	0·88	0·75	0·77	..	..
Lithia ..	4·23	4·04	4·09	5·08	4·08
Water ..	..	1·12	1·30	2·36	1·36
	102·37	..	102·33	103·51	102·17

From this comparison it is apparent that my formula which Rammelsberg declares incorrect, gives quantities which agree better with his analysis than those reckoned according to his formula; farther that my formula gives a percentage of water which is wanting in Rammelsberg, though all appearances point to its being present.

In the same way the data in reference to the lepidolite of Rozena may be added

	Rammelsberg.		T.	Berwerth.	T.
	Calc.	*Found.*	*Calc.*	*Found.*	*Calc.*
Fluorine ..	8·13	7·12	6·88	7·88	8·08
Silicic Acid	50·07	51·70	50·72	50·98	51·04
Alumina	28·54	28·03	27·99	27·80	28·17
Potash ..	11·19	10·29	10·95	10·78	10·28
Soda ..	1·21	1·10	1·20	..	..
Lithia ..	4·17	3·75	4·07	5·88	4·92
Water ..	..	0·30	1·08	0.96	0·91
	103·31		102·89	104·28	103·40

Here again is brought out the advantage of my formula, whilst it may be mentioned in reference to the quantity of water that Rammelsberg's method gives no satisfactory estimation.

After having thus shown how unjust is the reproach against my formula, it may again be stated here, viz., $3\,(Si_6, Al_6, K_6, O_{24}) + (Si_{10}, H_8, O_{24})$. With the first constituents it is also to be understood that the isomorphous Natrium and Lithium compounds are to be found. The second of the combinations cited will appear in the fluor-containing potash micas partly in the combination Si_{10}, O_8, Fl_{24}. In the estimations of Rammelsberg's analyses previously communicated as to the lepidolite of Paris the relations of the alkalies assumed are K. Na. Li as 10 : 1 : 11 for those of Rozena 6 : 1 : 7, whilst the relation of the hydrogen and the compound of fluor in both cases is 2 : 3 and 1 : 1. The estimate of Berwerth's analysis is derived from my treatise."

T. A.

Correspondence.

Letter from Capt. Marshall Hall to Prof. Heddle, with analyses of Serpentine.

Maison Allamand, Vernex-Montreux,

Canton Vaud, Switzerland, Oct. 2, 1879.

My dear Professor Heddle,

Seeing your interest in the formation of Serpentine, I venture to send you my figures as to three analyses made by me for David Forbes, who was "on" the question of Dolomite *versus* Serpentine. The minerals he told me were,—*i.e.* the first two—close neighbours, from Cornwall. Unfortunately he died before carrying out his investigations. Both rocks (pure minerals they were not), were translucent, light-green, but serpentinic, rather than Dolomitic, gave no peroxide of iron, indistinctly crystalline (if at all), and shewed, to the best of my recollection, no specks. Of course I have not got them here.

Cornish—from David Forbes.

	Dolomitic.	Serpentinic.
SiO_2	3·43 ..	39·48
FeO, Al_2O_3, &c.	1·15 ..	1·65
(Iron, all protoxide)		
CaO	13·37 ..	24·14
MgO	20·12 ..	18·16
CO_2	49·04 ..	13·83
H_2O and loss on ignition	12·91 ..	4·56
	100·02	101·82
Sp. Gr...	2·83	2·80
Insol. in HCl.	4·53	72·314

Traces of Organic Matter

Slight Manganese reaction.

Impure Serpentine (also from David Forbes) from Lissoughton, Galway.

FeO, &c.	2·452
CaO	5·207
MgO	38·173
SiO_2	37·332
CO	1·859
H_2O (ignition)	14·000
	99·083
Sp. Gr. (in lump)	2·50
Do. (in powder)	2·03
Insol. res. with HCl	38·010

Professor Renevier of Lausanne, is next year to bring out a book on th Vaudois Alps. M. Henri de Saussure sends me a lot of gabbros fr the Saas Thal, and when I have done some work in connection with Pr fessor Renevier's investigation, I propose to take these in hand. Ne spring I want to visit the Saas Thal, which I can reach in one long da from this house, and where I have not been since 1849.

Not wishing to be a martyr to science I shall *not* go till summer 1880. Meanwhile I hope to get the rocks to study and in part analyse, and so be prepared to look out for the points of alteration. Th gabbros (strictly euphotide) contain, I think, saussurite and diallage principal minerals, whilst another seems like hypersthenite, and contain labradorite (or saussurite), and hypersthene. But I am only to weak in my mineralogy, and with no chance in this healthy bu un-intellectual village of bettering my knowledge. I should like to liv at Lausanne, but it is so much colder. Meanwhile I should like to sen half of each stone to England, get sections cut, and somebody's opinio on the contained minerals. I think I see garnet, and there is lots c schistose serpentine connected with the gabbros. If you are interested enough you could compare these rocks with the Scottish forms, only I a in a "fix" that I did not get my stones from the locality myself, and ca tell but little about them till I go to the Saas-Thal. Curiously enoug the glaciers have brought down specimens to the lake side here!

I only wish I could induce *you* to come out and put your rocks side b side with the Valaisan stones. Without professing much I may lay clai to such a knowledge of the country as might do some service in the wa of direction.

By the bye I have not your method of silicate analysis *here*—you gave me a copy of your work—I wish it were published separately, how it would conduce to uniformity if all were to work by the same exact method, sinking small differences of opinion.

I am much exercised as to the way to estimate boracic acid. I forget if you give a method ?

Should you think anything in this letter of use for the Mineralogical Magazine pray send any extracts to it which seems unto you worth while.

Wishing you all in England and Scotland a merry Christmas two months hence.

Very truly yours,

MARSHALL HALL.

Professor M. Forster Heddle.

Obituary.

AGAIN we have to record the loss of a Member of our Society,—a contributor to our Magazine,—and again from the ranks of the Professoriate.

Henry How, Vice-President and Professor of Chemistry and Natural History in the University of King's College, Windsor, Nova Scotia, died on the 28th of September last, at the early age of 52.

We join with our Canadian friends in lamenting one who though a *naturalist* in the broad sense of the word, and a teacher of chemistry, was essentially and as a specialist, a *mineralogist*.

As such, even more than as a chemist, he distinguished himself in this country—as such he was received upon the other side of the Atlantic,—and as such he was labouring, and, as our own pages will show, writing, when his end came as a relief to long continued suffering.

As Professor How spent the last twenty years of his life in Nova Scotia, it is from those who were thrown into association with him there that we most fittingly must look for the truest vouchers of the worth of the man, and of the value of his work; and from the pages of the "Record" of his own University we extract the following notice.

"It was just as we were all on the eve of gathering at Windsor for the work of Michaelmas Term that the news reached us that the Vice-President of King's College was dead. Failing as his health had been for so long, we had scarcely expected so sudden an end to a life of considerable usefulness and activity. Every one who had come in contact with Dr. How had been struck with his honesty of purpose, his great love of science, his varied literary taste. From the moment he landed in this country, fresh from the wonderful laboratories of Europe, and glowing with enthusiasm for the prosecution of his favourite studies, he had lived a life of obscurity, almost seclusion. A few there were, and only a few,

who had come to appreciate his talent as an analyst, his great learning as a chemist, his industry in fields of original research. He had come to Windsor, Nova Scotia, as the first Greek scholars of the Renaissance came to England—pioneers of new studies. The missionary who endangers his life among the Maoris or the savages of Borneo, is scarcely more worthy of commendation than the sensitive, ardent man of science, who throws himself far from congenial minds, and congenial surroundings, into the raw, though not unkindly, community of a new country. It is not right that men should deny a just tribute to those who, if they be not the martyrs, have a fair claim to be called the missionaries of science.

"Twenty-five years ago the state of education in this province was not what it is now. King's College had not then her list of scientific alumni. There was no Dalhousie College with its zeal for physical research, turning out year by year young men well equipped for work in their native country, and encouraging the ablest of them to seek the completer knowledge of Leipsic or the London Schools. The earliest form that culture took in the Canadian provinces had been that of the Oxford of fifty or sixty years ago.

"These new countries were late in putting away the bigotry of learning which lingered in their midst, often allied, indeed, with the gentle and refining scholarship of these old European seminaries, which are only just beginning to break away from the shackles of mediæval pedantry. We believe that at last physical science is beginning to obtain the paramount prominence she has fairly won, not alone by her vast discoveries in the domain of phenomena, but by quickening and inspiring generally that fearless spirit of enquiry, which, within the last few years has done so much to clear away what have long been the reproach of theology and metaphysics. Our lamented friend has done something towards this consummation in Nova Scotia.

"The place of Professor How in the history of this Institution, and of this Province is that of one who first expounded to the youth of Nova Scotia, from the abundant resources of an accomplished mind, the doctrines of Faraday, Lyell and Agassiz. It would be difficult to base a plea for grateful remembrance and respect towards a professor of learning upon more solid grounds than these.

"Although a specialist in the best sense of the term, the late Professor was also a man of considerable general attainments.

"For many years before his death he suffered much excruciating pain and accompanying depression; but his pupils and colleagues never doubted

to the last his quick sense of the claims which others had on his consider
ation and courtesy, and his unwearied anxiety to discharge well his many
duties as Vice-President, Professor and Librarian."

Professor How was an industrious worker;—between the years 185
and 1876 he published twenty papers on mineralogical subjects. The style
of his contributions to our Magazine vouches for his enthusiasm.

M. F. H.

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